

Preliminary Draft

Feasibility Study Report, Operable Unit 1, Quanta Resources Site, Edgewater, N.J.

Submitted to
U.S. Environmental Protection Agency, Region 2

Submitted on behalf of
Respondents to Administrative Order on
Consent II-CERCLA-2003-2012

February 2009

CH2MHILL



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Executive Summary

This feasibility study (FS) report for Operable Unit 1 (OU1) of the Quanta Resources Superfund Site in Edgewater, New Jersey, adjacent to the Hudson River, has been prepared in accordance with CERCLA requirements pursuant to an EPA Administrative Order on Consent (AOC) and with EPA direction and input. The FS report addresses EPA requests that the Respondents provide a logical and consistent approach to addressing principal threat waste and low-level threat waste that is consistent with EPA guidance. As defined in the AOC, OU1 "shall mean the areas of the Site, including soil, debris and groundwater, westward of the Hudson River Bulkhead"; OU2 "shall mean the areas of the Site, including surface water and sediments, eastward of the Hudson River Bulkhead." OU2 is being investigated pursuant to a separate EPA AOC. The EPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP) and with public input, will use the FS information to select a remedial action alternative for OU1.

The site is well understood for purposes of supporting an OU1 remedial alternative development and evaluation. The primary components of the conceptual site model—including site setting and land use, geology and hydrogeology, and nature and extent of contamination—are discussed below, as are the data gaps that are being addressed as part of an ongoing supplemental remedial investigation (SRI). Data obtained as part of the ongoing SRI will supplement existing data and allow for sufficient characterization of human health risk at Block 93 Central and South and for groundwater at the site as a whole.

The purpose of this FS is to develop and evaluate a range of alternatives that protect human health and the environment, that maintain that protection over time, and that are consistent in defining and addressing the principal threat waste and potential risks at the site.

Site Setting and Land Use

The approximately 23-acre OU1 has been used for various purposes and has had multiple property owners. Prior to the mid-1800s, the site and surrounding areas were tidal marshlands associated with the Hudson River. Development included the systematic infilling of these marshlands with a variety of materials, some containing polycyclic aromatic hydrocarbons (PAHs) and heavy metals at concentrations exceeding present-day regulatory soil cleanup criteria and contributing to the presence of these constituents in groundwater.

Numerous entities operated at the site from the latter part of the 1800s up until 1981. From approximately 1872 to 1971, a large portion of the site was used to process coal tar and to produce paving and roofing materials. From 1974 to 1981, a portion of the site was reoccupied and leased for oil recycling. Aboveground and underground storage tanks were subsequently removed, and that portion of the site has remained vacant since. A former sulfuric acid plant generated elevated concentrations of arsenic (and to a lesser extent, lead) in oxidizing pyrite ore in a portion of OU1 that partially overlaps with the location of former

coal tar operations. This area is the subject of an NJDEP Administrative Consent Order. A number of commercial buildings and roads are currently located on portions of OU1.

Geology and Hydrogeology

OU1 soil consists predominantly of historic fill material contaminated with PAHs and metals overlying deposits of native sand and organic silt, including peat. Heterogeneous fill material contains constituents of interest (COIs) in concentrations that exceed regulatory soil cleanup criteria and contribute to the presence of constituents in groundwater that also exceed regulatory criteria; the fill contain boulders and large debris, which could complicate the implementation of remedial actions.

These upper stratigraphic units are underlain by a silty-clay aquitard, the top of which is located at a depth of 10 to 30 feet below ground surface (bgs). The undulating surface of this unit pinches out against the bedrock high to the north of the site (the former Celotex property) and forms a natural depression in the central portion of the site. A confined, water-bearing deep sand unit lies below portions of the aquitard and above bedrock.

Depth to groundwater is shallow on the Quanta property (ranging from 0.5 to 6 feet bgs), and the flow direction of unconfined groundwater is to the east and south. A tidally influenced mudflat or marsh associated with the Hudson River borders OU1 immediately east of the wooden bulkhead. These mudflat sediments consist of organic silt to clayey silt greater than 50 feet thick.

Conceptual Site Model

Non-aqueous phase liquid (NAPL) is present primarily in the form of residual and free-phase dense NAPL in shallow soils above and on top of the aquitard. NAPL physical characteristics such as viscosity are variable throughout OU1. Most free-phase NAPL is present in discrete areas (or zones) above and within the top few feet of the silty clay confining layer. The results of the final remedial investigation report¹ indicate that NAPL at OU1 is generally stable under current conditions. Migration is constrained by the physical properties of the NAPL (e.g., high viscosity and interfacial tension), the soil pore size, and physical barriers such as the silty clay confining unit and shallower organic silt deposits. Tar boils occur during the summer months when solid tar in the shallow unsaturated zone becomes heated enough to seep upward to the ground surface through cracks in soil or pavement.

The presence of sheens and NAPL in areas of OU2 adjacent to NAPL-impacted zones, indicate that it is possible that some migration of NAPL is occurring from OU1 to OU2. Additional evaluations being performed as part of the SRI will provide further information on the potential for NAPL migration in these nearshore areas.

The draft baseline human health risk assessment² evaluated the potential risk at the site and identified the constituents of concern (COCs) for surface soil, subsurface soil, and

¹ CH2M HILL. 2008. Final Remedial Investigation Report, Quanta Resources Superfund Site, Operable Unit 1. August.

² CH2M HILL. 2007. Draft Baseline Human Health Risk Assessment, Quanta Resources Superfund Site, Operable Unit 1. November.

groundwater, which consist primarily of semivolatile organic compounds (SVOCs) (predominantly PAHs), aromatic volatile organic compounds (VOCs), metals, and, to a lesser extent, chlorinated VOCs, pesticides, and polychlorinated biphenyls (PCBs). Of the COCs identified, arsenic (in the reduced arsenite species [As III]), PAHs (primarily benzo(a)pyrene, dibenz(a,h)anthracene, benzo(b)fluoranthene, and benzo(a)anthracene), and naphthalene are considered the primary risk drivers for most media and receptors evaluated. The remedial action alternatives target these primary risk drivers as well as NAPL (a source of PAHs and naphthalene) by eliminating exposure pathways, thereby eliminating potential risk to human health and the environment.

Concentrations of COCs in groundwater have generally been constant over time and decline with distance from sources, as evidenced by concentration versus time plots and plots of groundwater plumes over time for key constituents. The footprint of the composite extent of COIs in groundwater is not expanding as a result of attenuation mechanisms including adsorption and degradation processes evidenced by the geochemistry of groundwater.

The remedial alternatives that are evaluated within this FS report address the presence of principal threat source material and dissolved phase COCs by eliminating exposure pathways, thereby eliminating potential risk to human health and the environment.

Supplemental Remedial Investigation

Supplemental site characterization activities are ongoing, but remedial investigations have been carried out at OU1 and reported in the final remedial investigation report. The SRI is under way to address uncertainty for the following topics:

- Groundwater flow paths and the distribution, fate, transport, and attenuation of NAPL constituents and arsenic across the groundwater-surface water transition zone between OU1 and OU2 (needed for the FS groundwater remedy)
- OU1 nature and extent of NAPL adjacent to the wooden bulkhead (needed to finalize the extent of NAPL remedy)
- Physical characteristics of the bulkhead and its role in limiting NAPL migration (needed for evaluation of FS remedial alternatives)
- Distribution, mobility, and stability of arsenic and NAPL constituents in groundwater within and downgradient of suspected source zones (needed for the FS groundwater remedy)
- Delineation of NAPL and arsenic in several site areas (needed to update the extent of soil remedy and associated costs)

The SRI results will require components of the remedial action alternatives to be revised. Therefore the alternatives will be reviewed following an evaluation of the SRI data.

Applicable or Relevant and Appropriate Requirements, Remedial Action Objectives, and Preliminary Remediation Goals

Applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), and preliminary remediation goals (PRGs) were developed for OU1, in accordance with CERCLA guidance, to define the extent of contaminated media requiring remedial action and to support development of remedial action alternatives that will protect human health and the environment and comply with ARARs.

The following RAOs were identified to mitigate the potential risks associated with the site:

Principal Threats

1. Remove, treat, or contain free product pursuant to NJAC 7:26E-6.1(d)
2. Prevent human exposure to NAPL and arsenic source material that poses human health risk in excess of 10^{-3} ELCR
3. Prevent current or potential future migration of free-phase NAPL to the Hudson River or to areas that would result in direct contact exposure
4. Prevent migration of source material that poses a potential source of vapor intrusion and resulting inhalation exposure within existing or potential future structures, to the extent practicable

Low-Level Threat Source Material

1. Prevent/minimize potential human exposure through contact, ingestion, inhalation (dust), or vapor intrusion that presents unacceptable risk
2. Prevent/minimize potential erosional transport offsite or to OU2 of site COCs at concentrations posing unacceptable risk
3. Remove, treat, or contain free and residual product pursuant to NJAC 7:26E-6.1(d)

Groundwater

1. Prevent/minimize potential exposure by contact, ingestion, inhalation/vapor intrusion that presents unacceptable risk
2. Prevent migration and preferential flow of COCs to OU2 at levels resulting in risk above acceptable levels to human health or ecological receptors

NJAC, New Jersey Administrative Code; ELCR, excess lifetime cancer risk; HI, hazard index.

Restoration of groundwater to drinking water quality at the site is technically impracticable due to the regional contaminated and heterogeneous fill, offsite contaminant sources, and

the presence of NAPL throughout the site. In addition, site groundwater is not suitable for drinking water due to its shallow depth, saltwater intrusion, and urban runoff. A technical impracticability waiver of specific ARARs is being requested for onsite groundwater; however, further migration of the plume and exposure to contaminated groundwater will be prevented, and groundwater discharging to OU2 will meet ARARs.

Principal Threat Evaluation

OU1 data were evaluated to determine the locations of principal threat and low-level threat wastes in accordance with EPA guidance. Principal threat wastes are considered to be highly toxic or highly mobile source material that generally cannot be reliably contained or would potentially present a significant risk should exposure occur. Low-level threat wastes are source material that generally can be reliably contained and would pose only a low potential risk in the event of exposure. This FS proposes to treat principal threat wastes, wherever practicable. Of the eight OU1 areas containing source material, the following are addressed in this FS as principal threats: NAPL zones NZ-1, NZ-2, and NZ-5; tar boils; and the portion of the high-concentration arsenic area (HCAA) (i.e., area with arsenic concentrations in soil exceeding 336 mg/kg) on the Quanta property and Block 93 North. NAPL zones NZ-3 and NZ-4, as well as the portion of the HCAA on the Celotex property, were determined to be low-level threat wastes. Evaluation of the presence of NAPL in NZ-4 is ongoing as part of the SRI. These source areas are shown in Figure ES-1 and ES-2.

Technology Screening

In a manner consistent with the RAOs and PRGs, remedial technologies were identified for free-phase NAPL, soil, and groundwater. Technologies generally fell within the categories of (1) no further action (NFA), (2) institutional controls, (3) monitored natural attenuation (MNA), (4) containment, (5) in situ treatment, and (6) extraction and ex situ treatment/disposal. Technologies were then screened on the basis of technical implementability, effectiveness, and relative cost.

Technologies retained for free-phase NAPL remediation included NAPL recovery trenches and wells, in situ solidification/stabilization, other in situ treatment (such as chemical oxidation), in situ permeable reactive barrier (PRB), and funnel-and-gate system.

Those retained for soil remediation included institutional controls, soil cover, soil multilayer cap, in situ solidification/stabilization, other in situ treatment (such as chemical oxidation), and excavation followed by treatment or disposal.

Those retained for groundwater remediation included institutional controls, MNA, subaqueous reactive barrier, in situ treatment (such as chemical oxidation), and extraction/treatment/disposal.

Remedial Action Alternatives

On the basis of the potential risks present at the site and the remaining remedial technologies available after the screening was completed, five alternatives were assembled

that use varying combinations of technologies to mitigate potential risks posed by principal threat, low-level threat source material, and groundwater through removal, treatment, or elimination of the exposure pathway. The implementations of each of the five alternatives are presented conceptually in Figures ES-3 through ES-12. Each alternative was then evaluated against the seven criteria identified in the National Contingency Plan (NCP). As required, NFA is included as Alternative 1 for comparison to remedial action alternatives.

All alternatives, with the exception of NFA, include the following components to achieve RAOs for areas outside the defined NAPL and HCAA zones, indoor air, and groundwater:

- Soil capping
- Institutional controls to prevent exposure to COCs in soil and groundwater
- Vapor intrusion mitigation at the 115 River Road building, and other buildings if needed
- A subaqueous reactive barrier (SRB) to treat groundwater discharging to the Hudson River

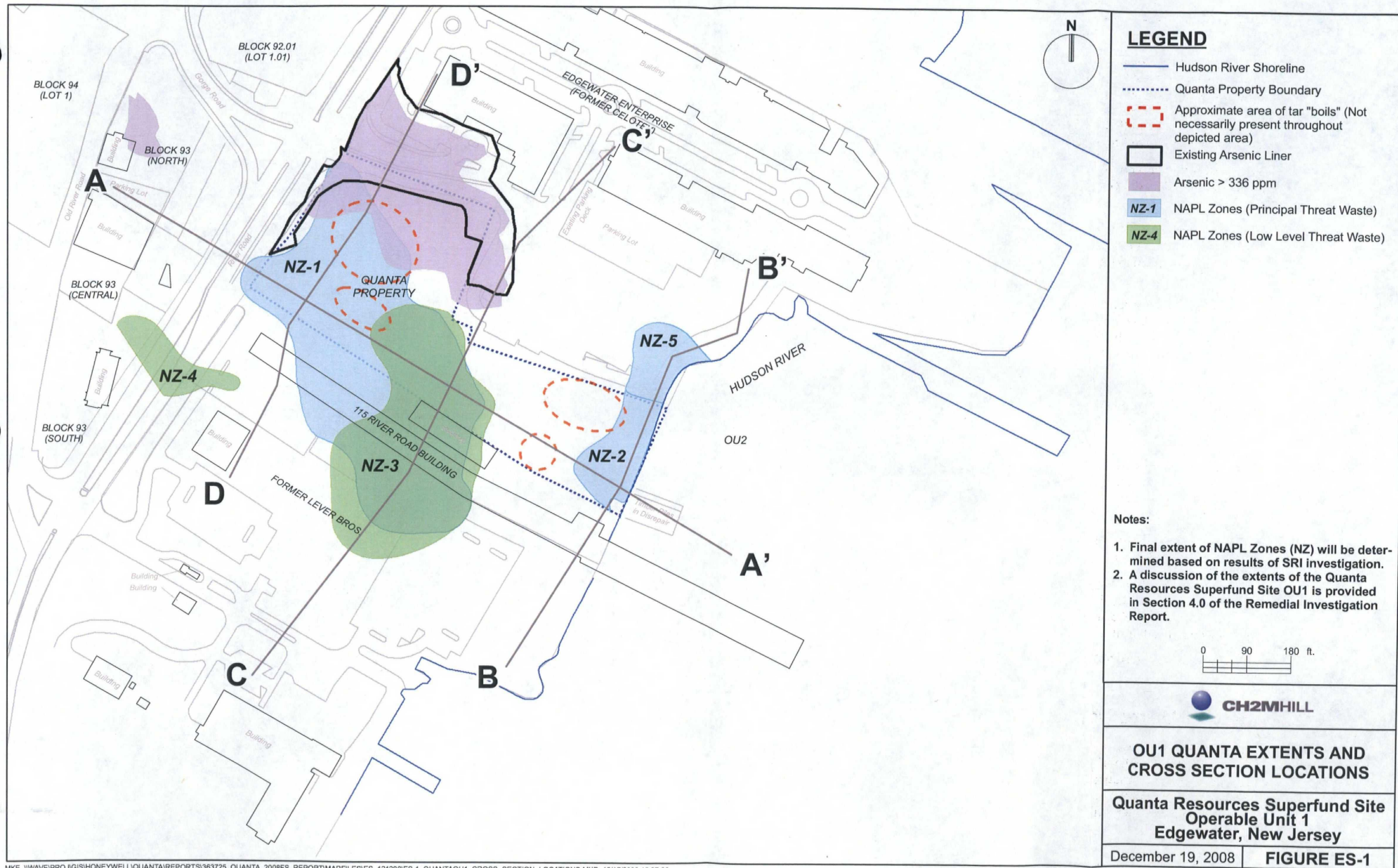
The use of the SRB for groundwater is a contingency component of the proposed remedial alternatives to address uncertainty related to the degree of attenuation of OU1 dissolved-phase constituents and residual NAPL, which could result in sheens, prior to their being discharged to OU2. The SRB would address the corresponding risk, if any.

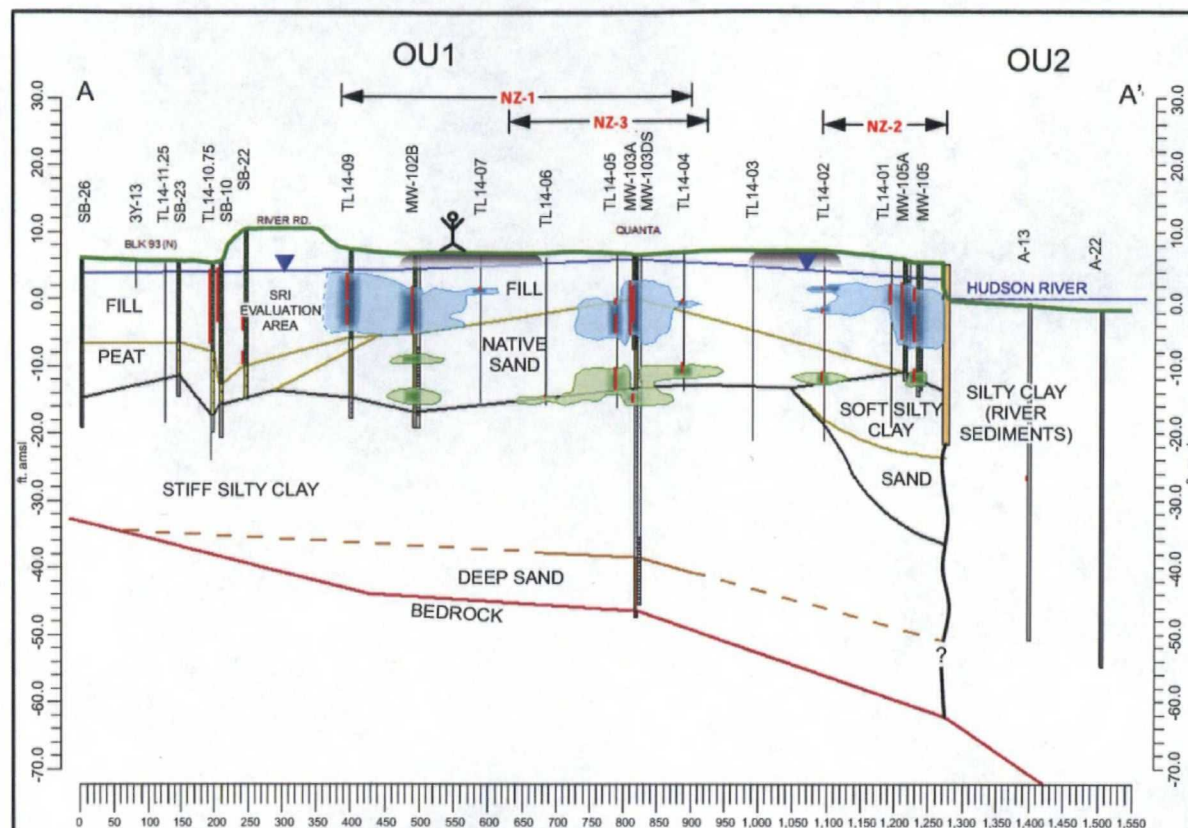
The manner in which the alternatives address principal threat waste is summarized below:

- **Alternative 2—containment:** NAPL is recovered from wells and trenches in NZ-1, NZ-2, and NZ-5; potential NAPL migration to the Hudson is mitigated by a PRB or funnel and gate. HCAAs are capped.
- **Alternative 3—excavation, containment, and in situ solidification/stabilization:** Tar boils, NZ-1, and NZ-2 are excavated to a depth of 4 feet bgs; NAPL is recovered from wells and trenches in NZ-1, NZ-2, and NZ-5; and potential NAPL migration is mitigated by a PRB or funnel and gate. HCAAs are solidified/stabilized in situ.
- **Alternative 4—in situ solidification/stabilization:** Tar boils, NZ-1, NZ-2, NZ-5, and the HCAAs are solidified/stabilized in situ.
- **Alternative 5—in situ solidification/stabilization and other in situ treatment:** Tar boils, NZ-1, and NZ-2 are excavated to a depth of 4 feet bgs; NAPL is recovered from wells and trenches in NZ-1, NZ-2, and NZ-5, and this is followed by in situ treatment. The HCAAs are solidified/stabilized in situ.
- **Alternative 6—excavation:** Tar boils, NZ-1, NZ-2, NZ-5, and HCAAs are excavated and disposed of offsite.

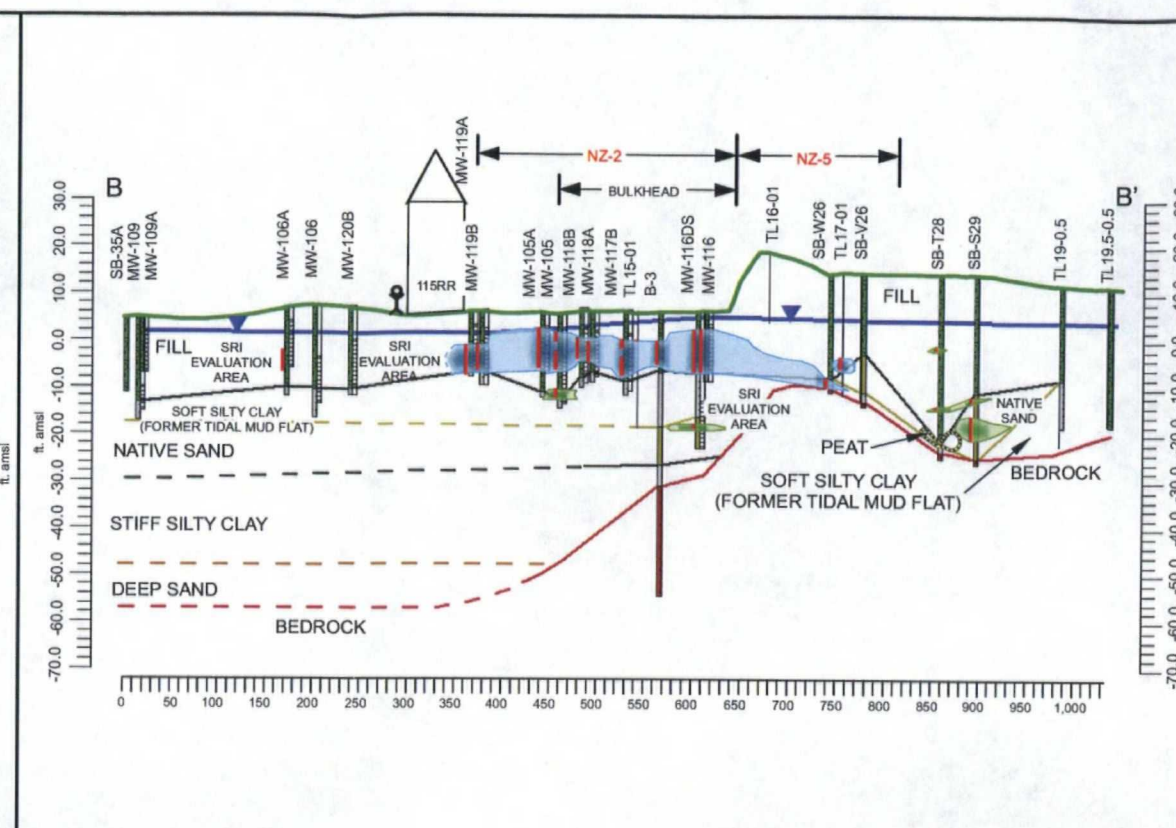
Detailed Analysis of Alternatives

A comparative analysis of Alternatives 2 through 6 is summarized in Table ES-1, indicating how each successfully mitigates potential risk associated with principal threat waste and how each relates to other contaminant source considerations. Table ES-1 also summarizes how the alternatives address seven of the nine NCP criteria that are applicable at this stage of the FS process. Evaluation of the alternatives against the seven NCP criteria indicate that

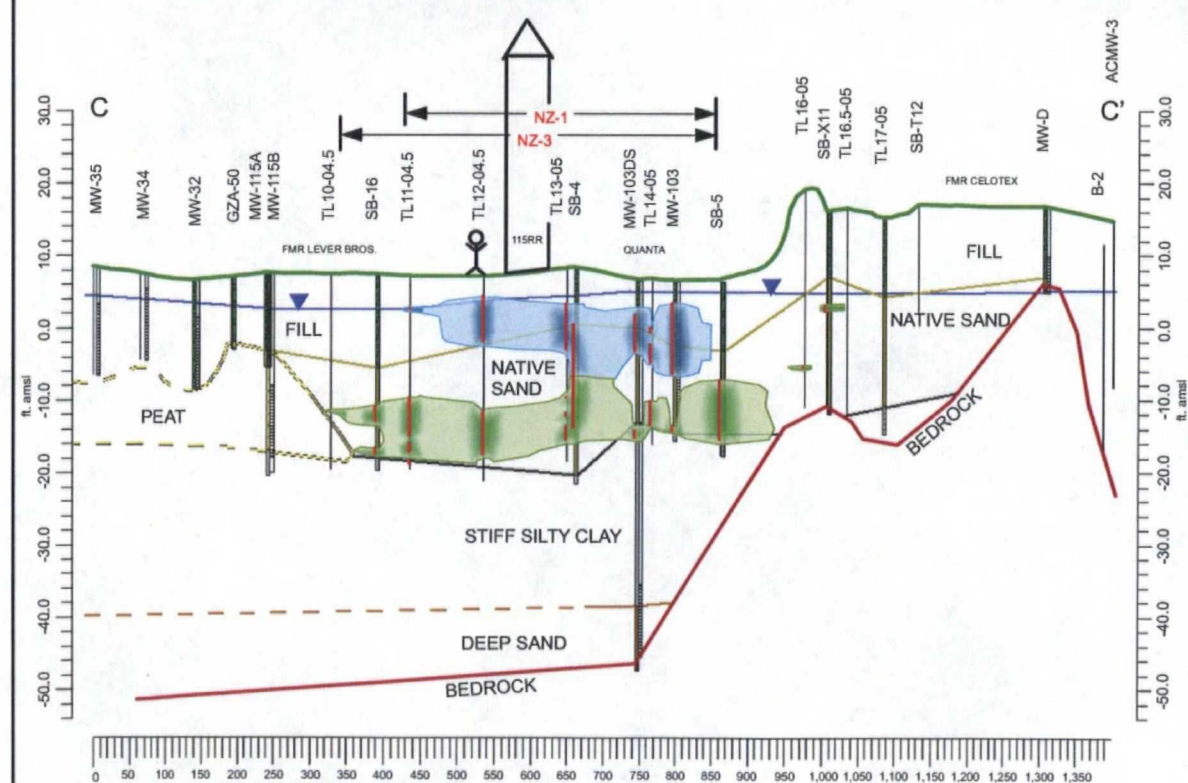




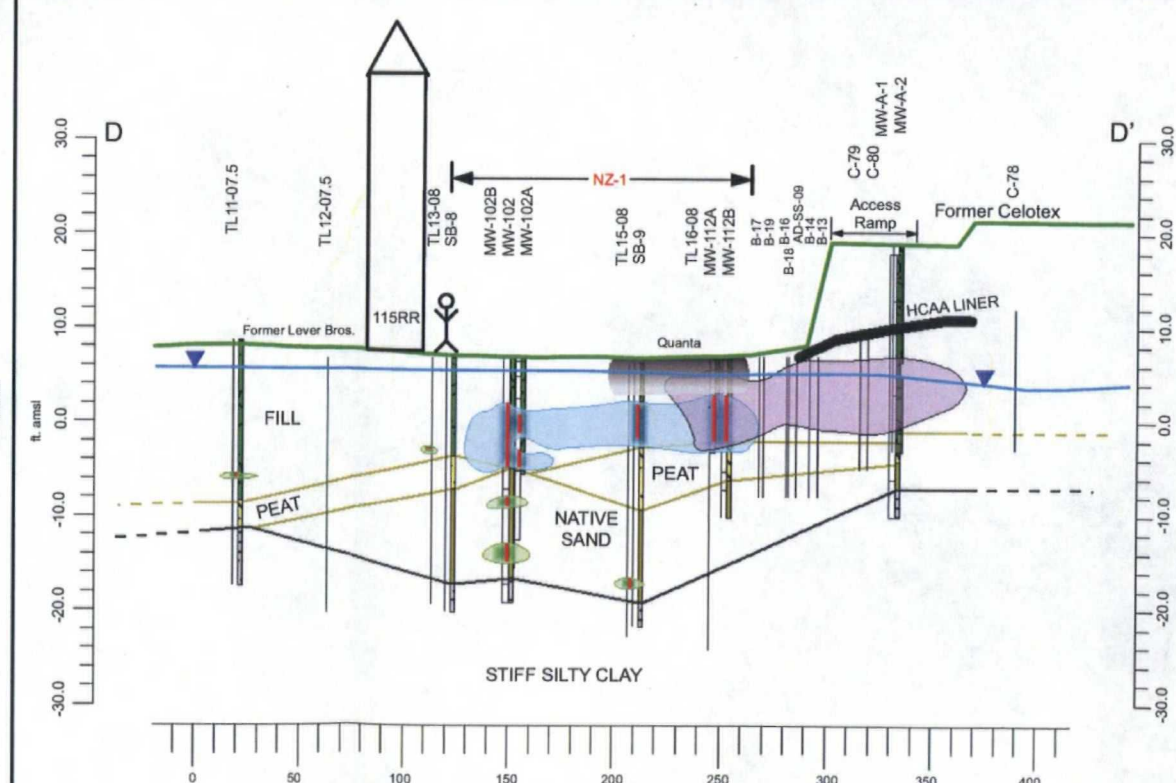
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CROSS-SECTION B - B'



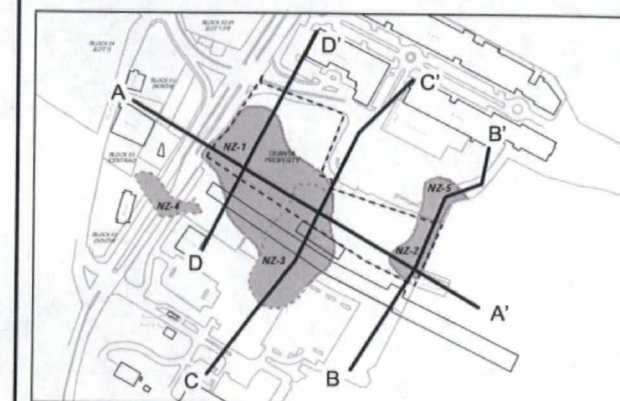
CROSS-SECTION C - C'



CROSS-SECTION D - D'

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Wooden Bulkhead (Depth Unknown)
- Tar Boils
- Stratigraphy
- Fill
- Silty-Clay
- Native Sand
- Peat
- Deep Sand
- Bedrock



Plan view of the Quanta Resources Superfund Site

Note:

- Extent of NAPL is not representative of recoverable NAPL and final extent will be determined in the SRI.
- Gradation of NAPL and tar boil shading is approximated for visual depiction.
- Interval of observed NAPL based on boring logs and TarGOST responses.
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- ft. = feet
- amsl = above mean sea level
- Nature of OU1/OU2 boundary will be determined in the SRI.

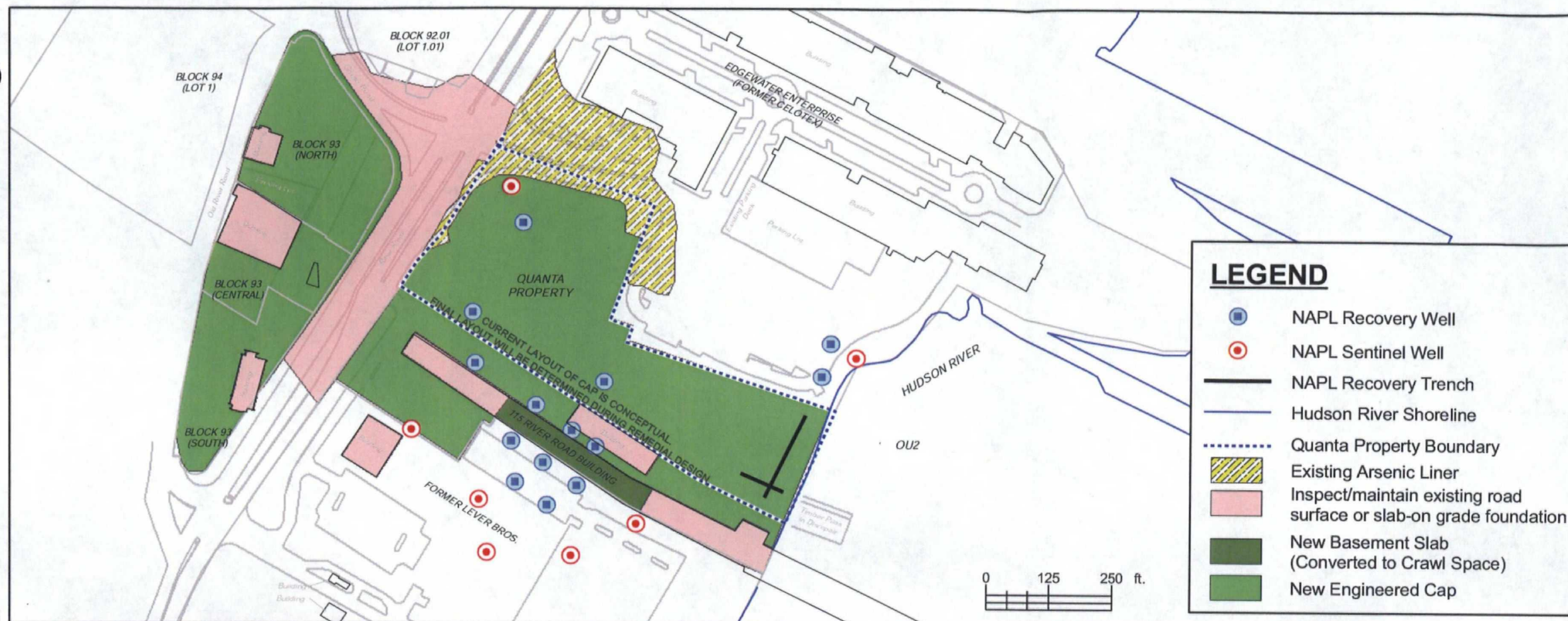


QUANTA OU1 CROSS SECTIONS

Quanta Resources Superfund Site
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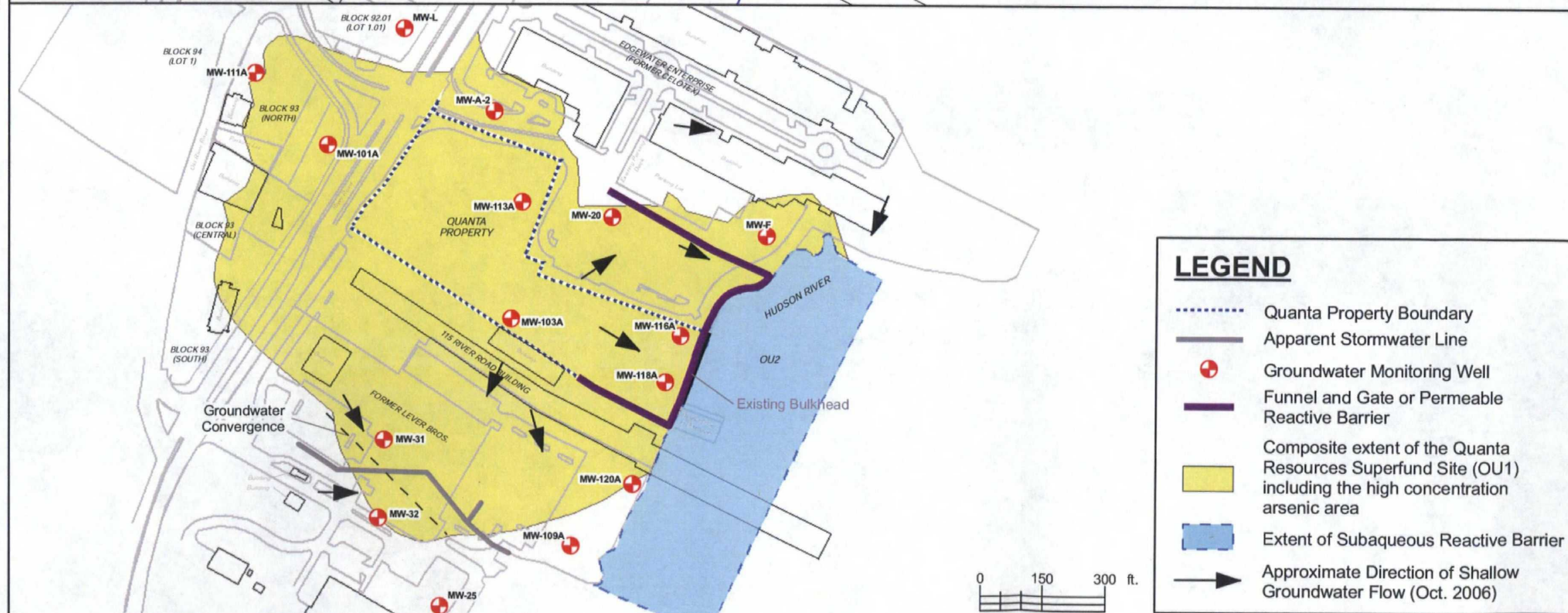
December 19, 2008

FIGURE ES-2



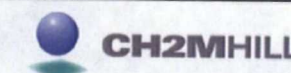
Notes:

1. Surface soils south of 115 River Road will be addressed with redevelopment of the former Lever Bros. property.
2. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
3. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
4. Final recovery and sentinel well layout will be determined during remedial design.



Note:

1. Approximate shallow groundwater direction based on conditions in October 2006.
2. Groundwater modeling will be performed to predict future flow direction.

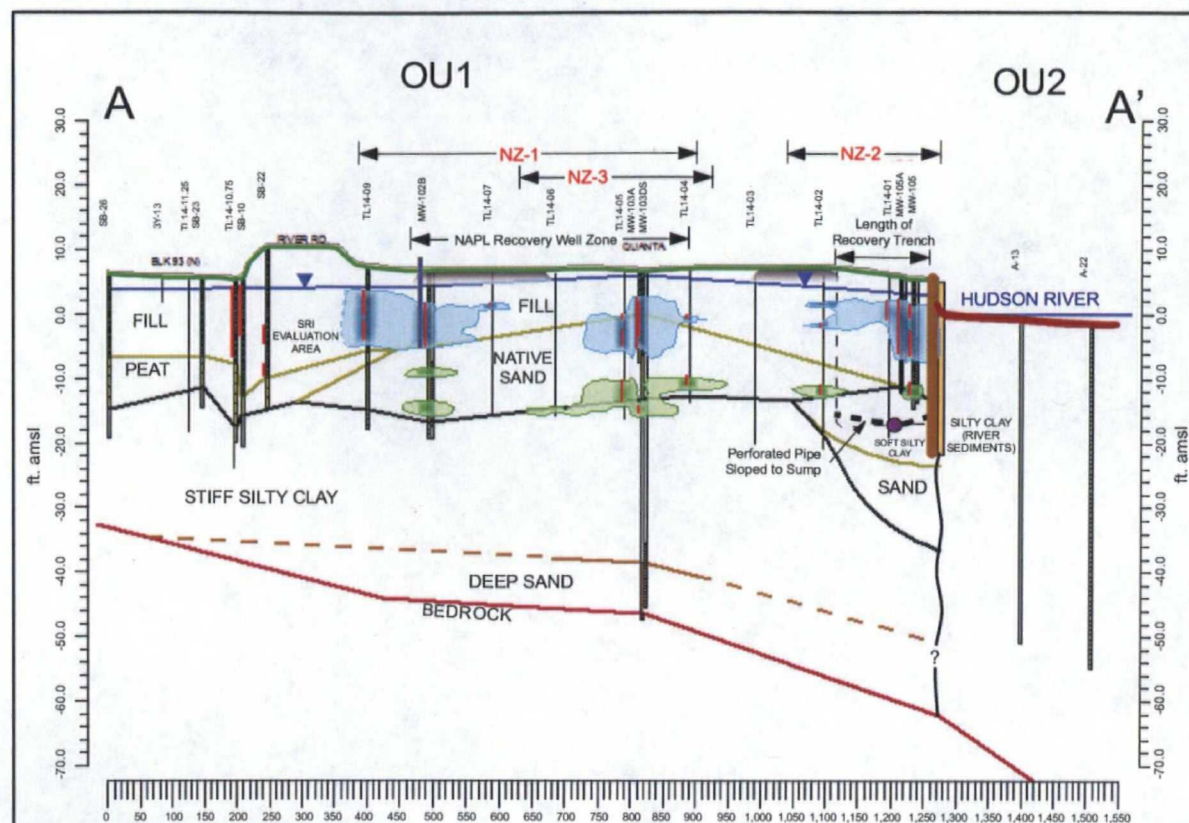


ALTERNATIVE 2 - PLAN VIEW

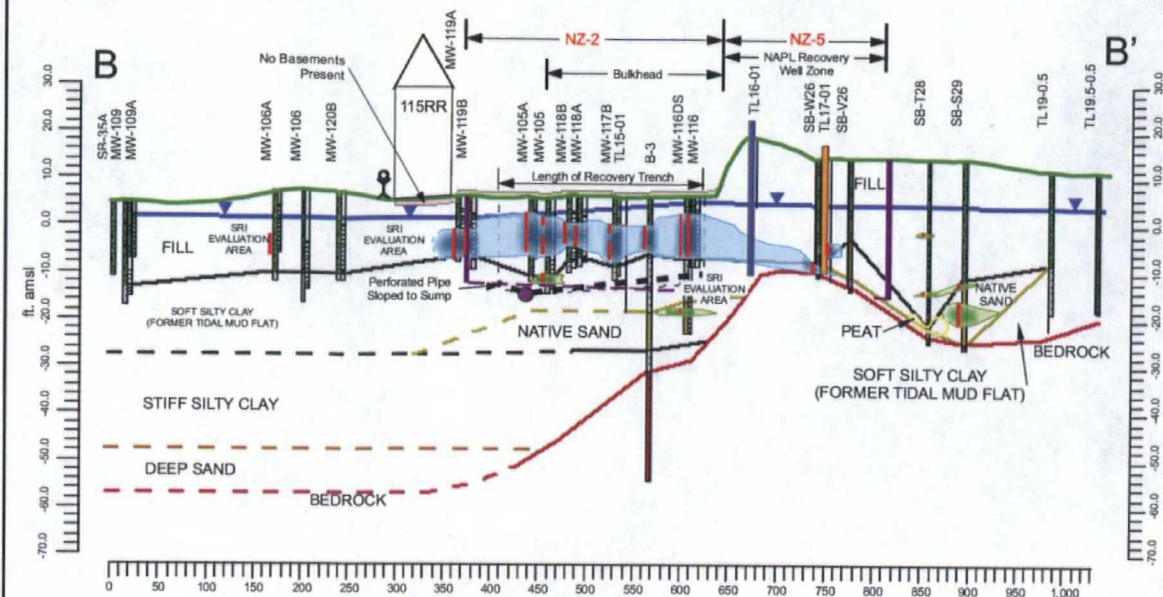
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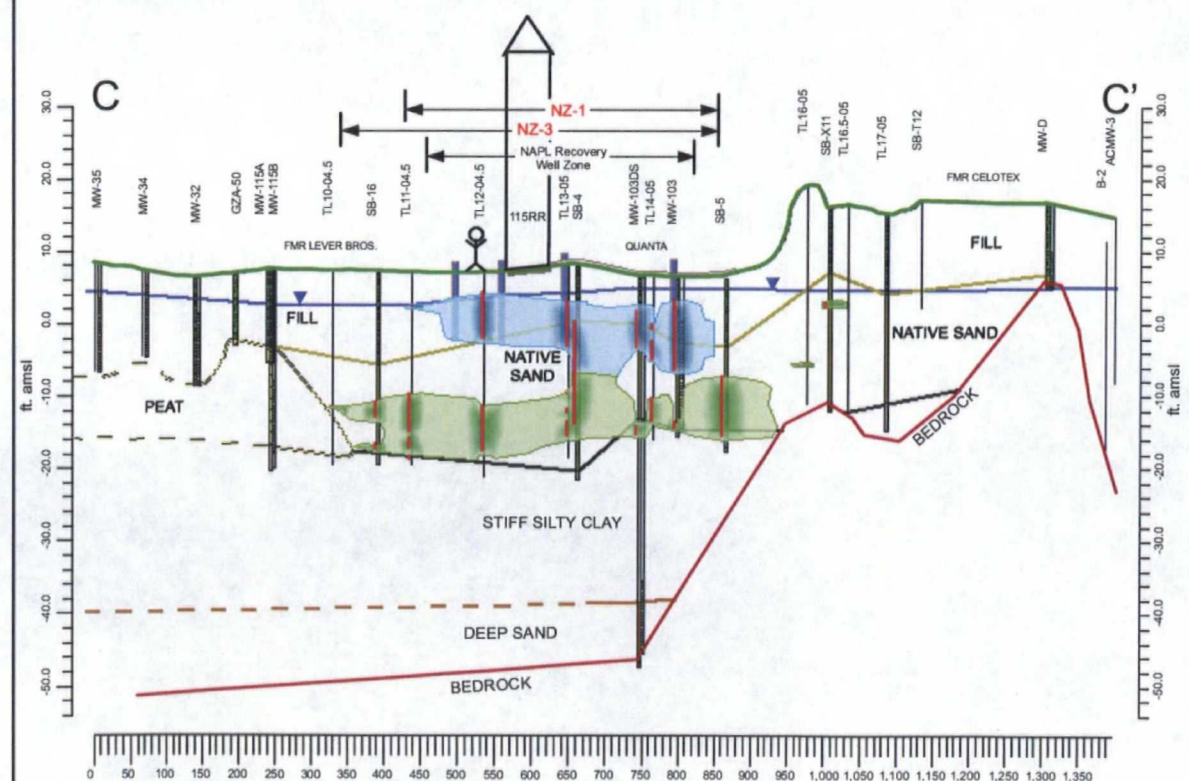
FIGURE ES-3



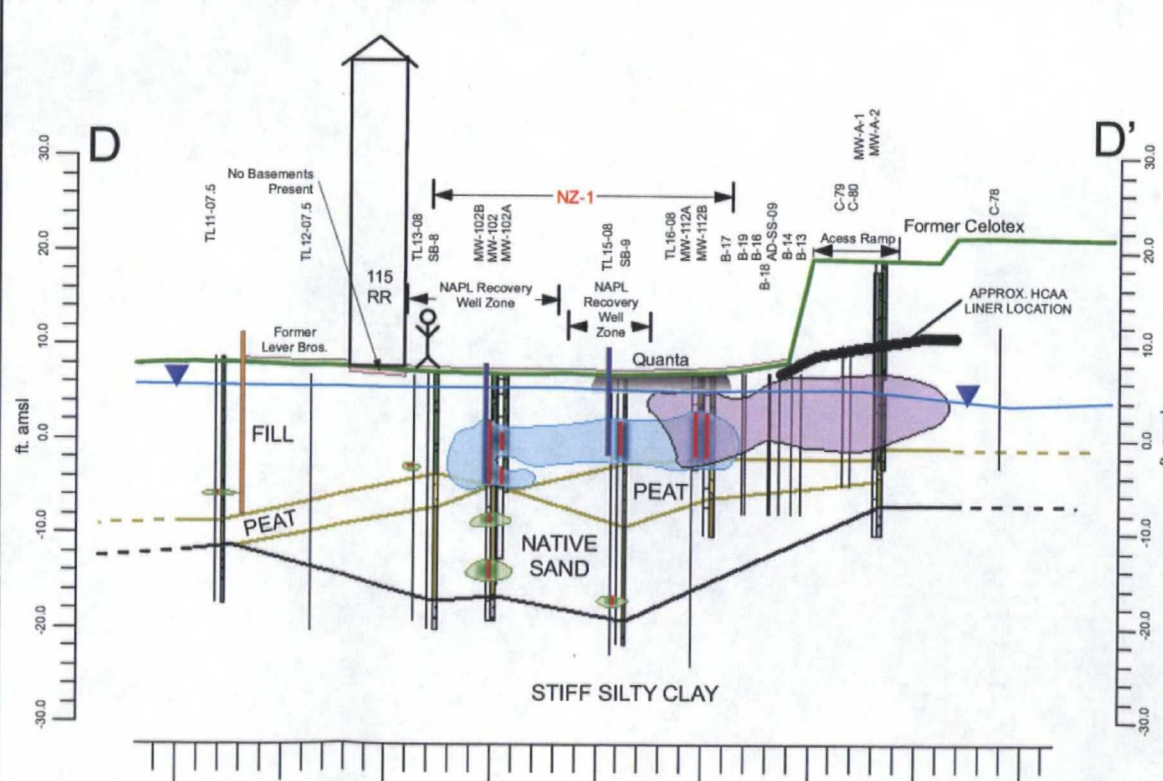
CROSS-SECTION A-A'



CROSS-SECTION B-B'

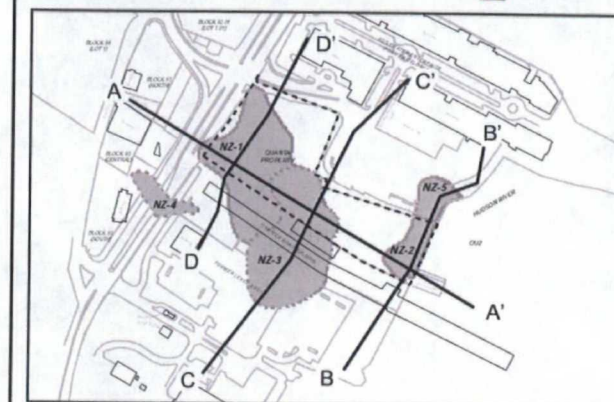
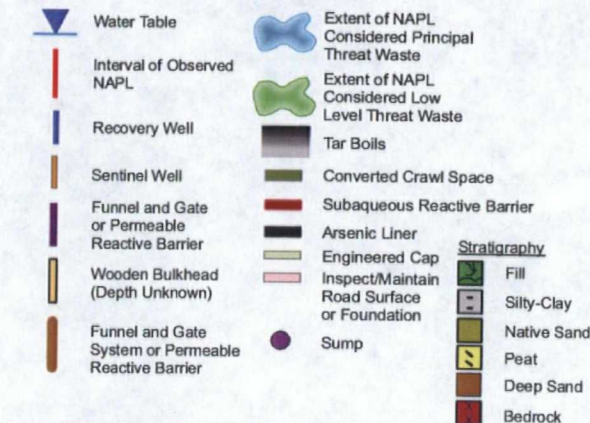


CROSS-SECTION C-C'



CROSS-SECTION D-D'

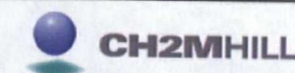
LEGEND



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL and final extent will be determined in the SRI.
2. Gradation of NAPL and tar boil shading is approximated for visual depiction.
3. Interval of observed NAPL based on boring logs and TarGOST responses.
4. Water table elevation depiction based on synoptic measurements taken in October 2006.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
amsl = above mean sea level
7. Nature of OU1/OU2 boundary will be determined in the SRI.
8. 115 River Road dimensions are estimated
9. Recovery trench shown parallel to cross-section line, trench width will be 3-4 ft.



ALTERNATIVE 2 - CROSS SECTIONS

Quanta Resources Superfund Site
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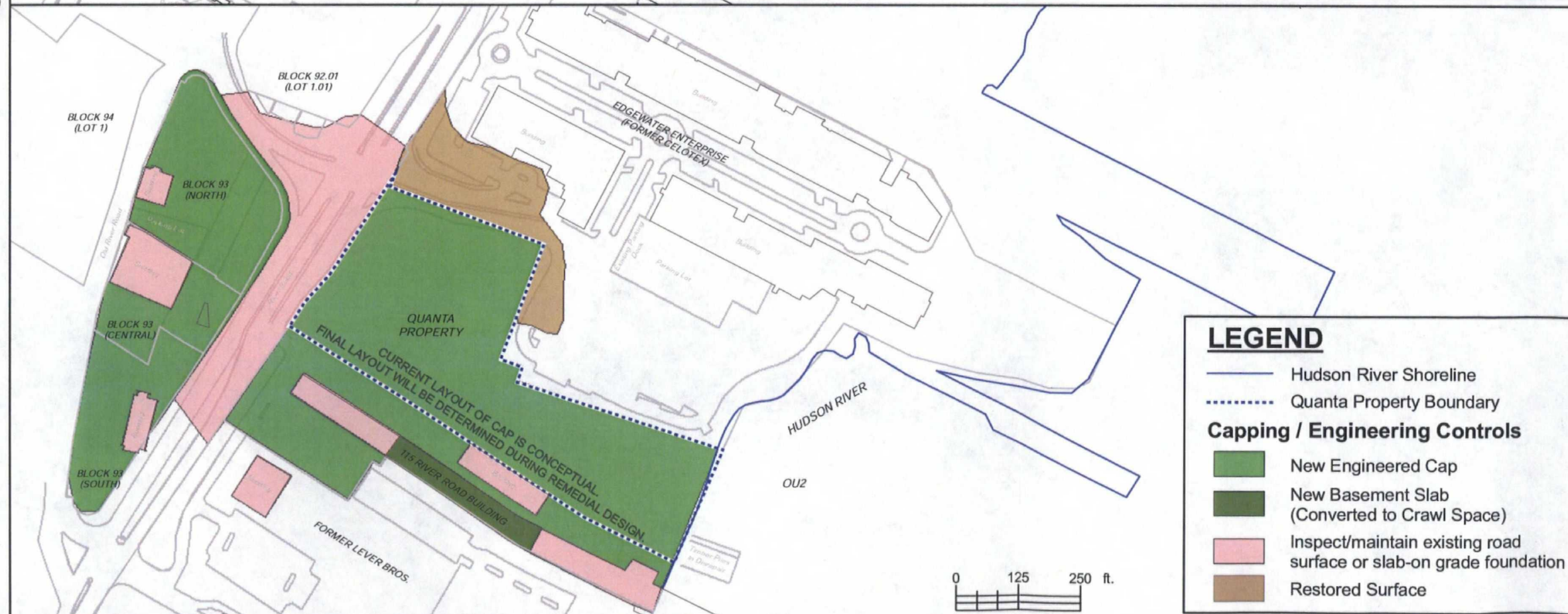
February 19, 2009

FIGURE ES-4



Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Final recovery and sentinel well layout will be determined during remedial design.



Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Cutoff wall implemented if necessary for redevelopment prior to OU2 decision.
3. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
4. Required extent of new engineered cap as shown; final extent to be determined during remedial design.
5. Surface soils south of 115 River Road will be addressed with redevelopment of former Lever Bros. property.
6. Disturbed surfaces will be restored to previous conditions after remediation.

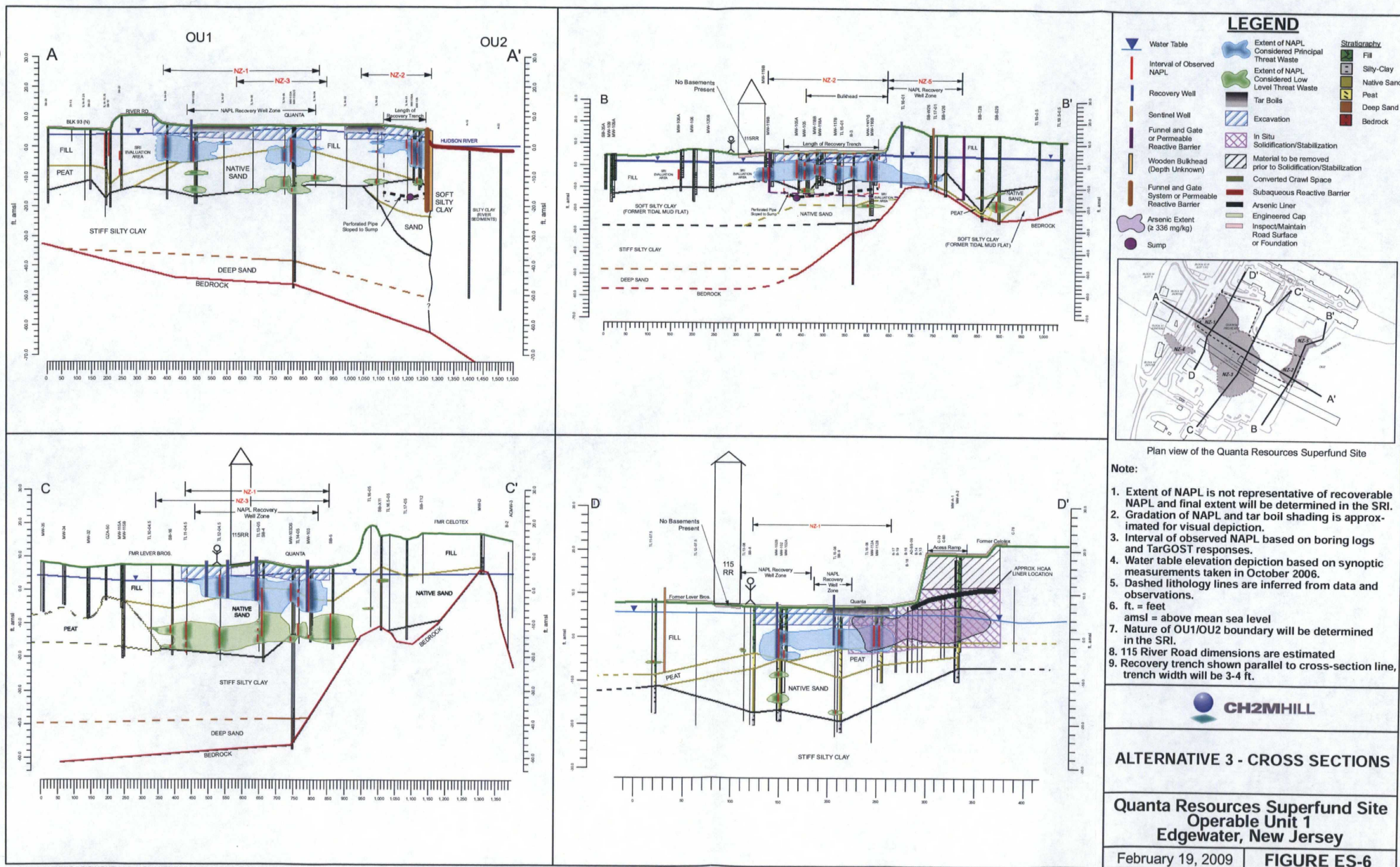


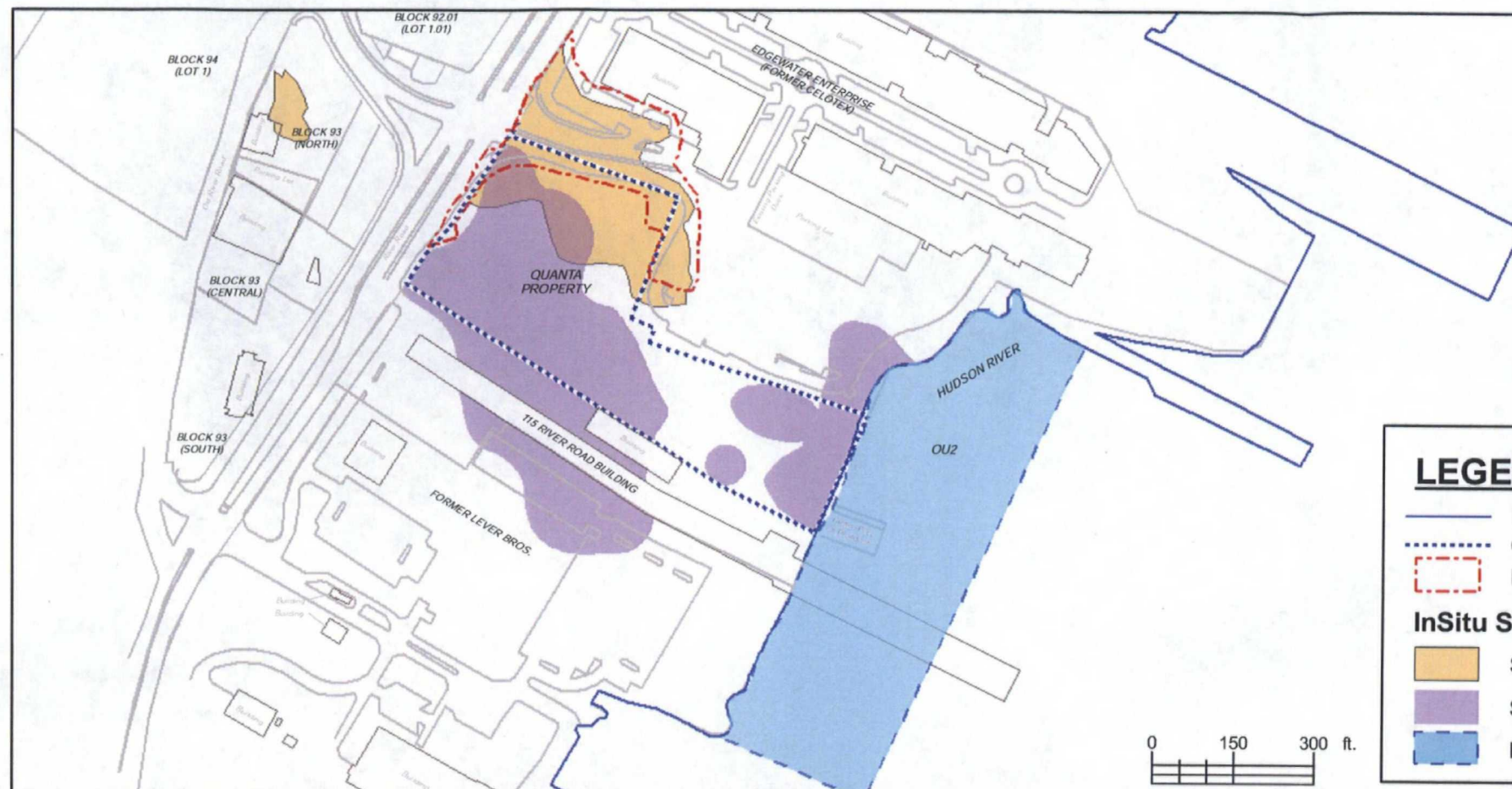
ALTERNATIVE 3 - PLAN VIEW

**Quanta Resources Superfund Site
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FIGURE ES-5





Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Cutoff wall implemented if necessary for redevelopment prior to OU2 decision.
3. Temporary access to Former Celotex property may be requested during stabilization activities.



Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Disturbed surfaces will be restored to previous conditions after remediation.
3. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
4. Surface soils south of 115 River Road will be addressed with redevelopment of former Lever Bros. property.

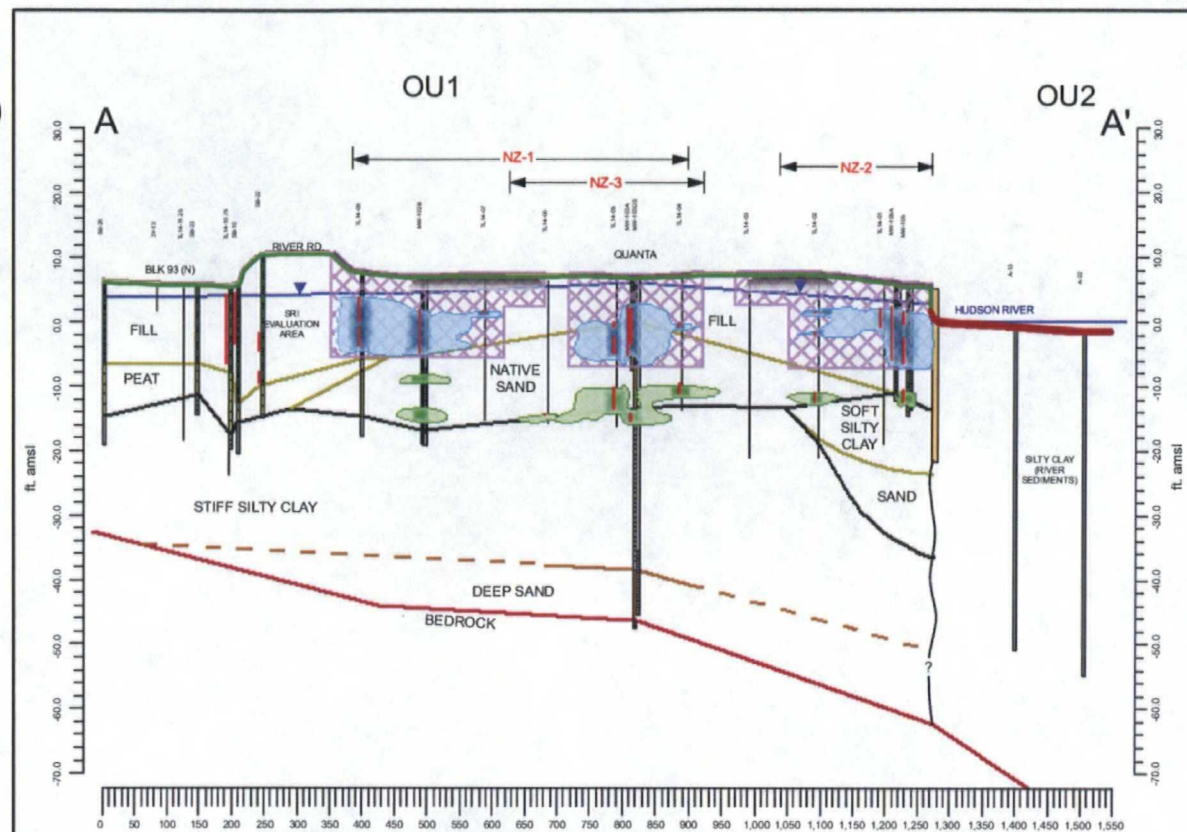


ALTERNATIVE 4 - PLAN VIEW

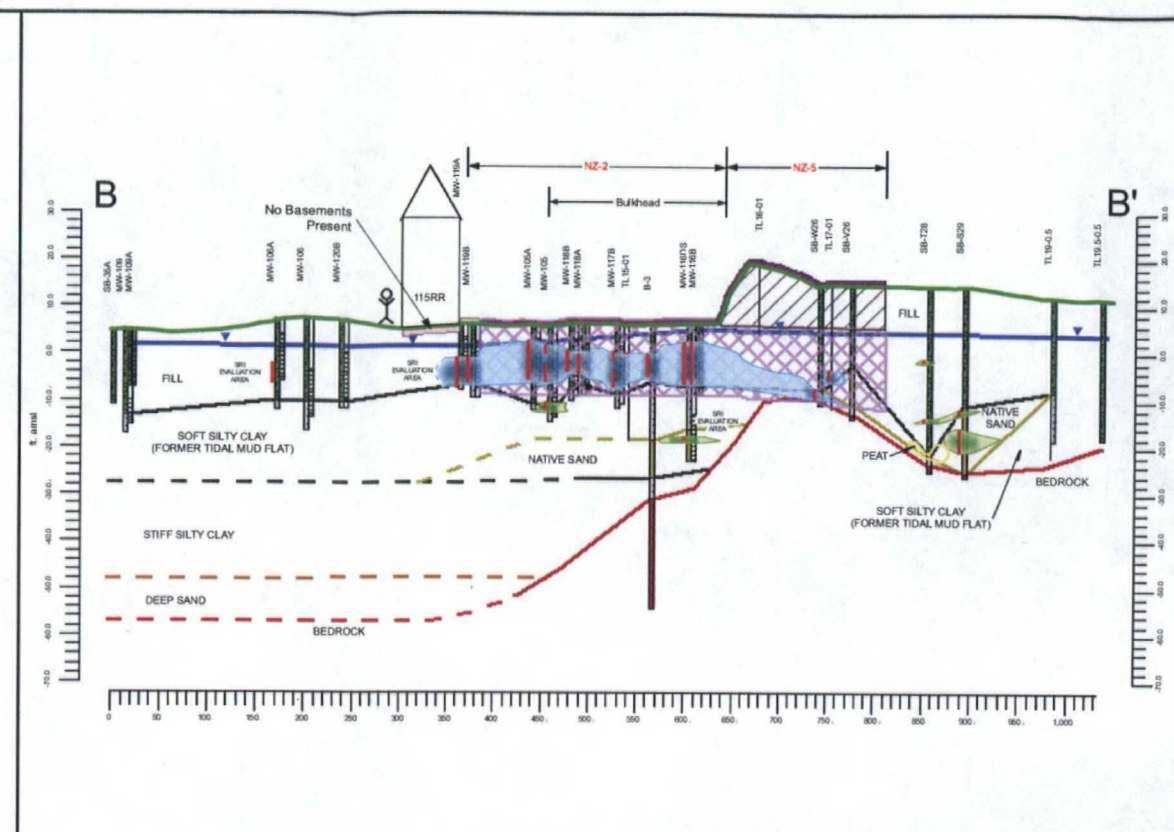
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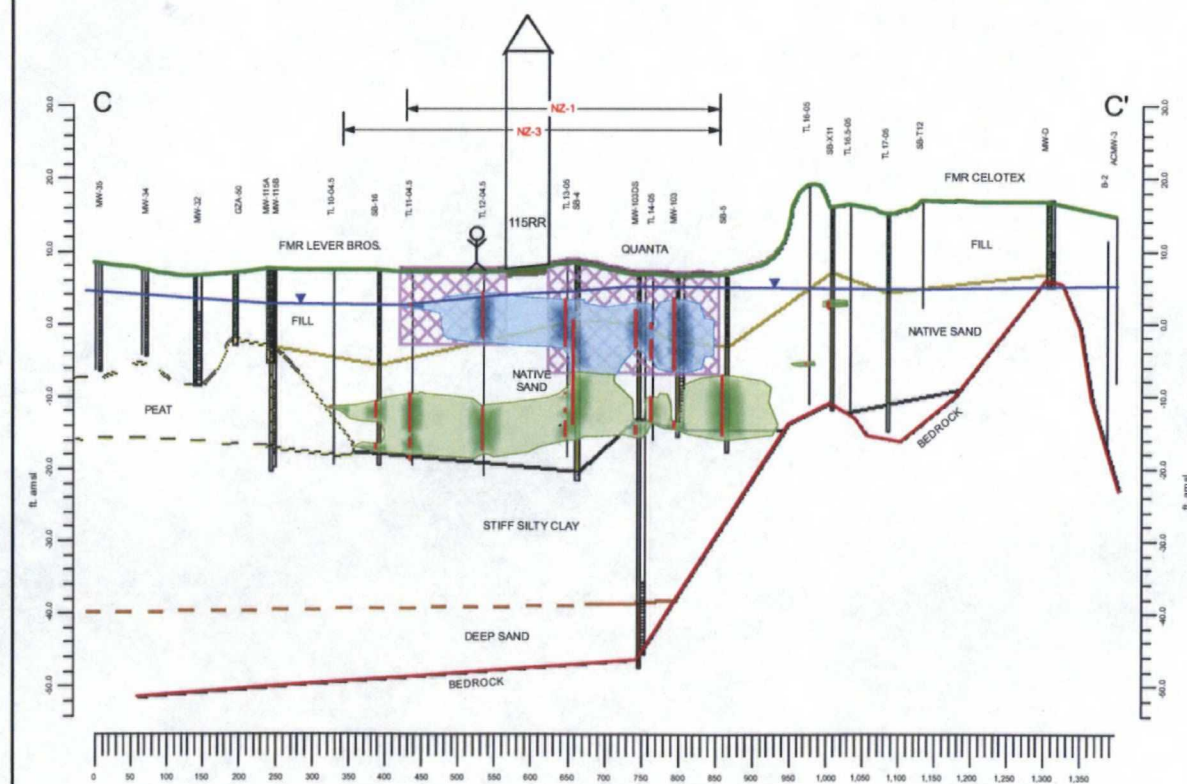
FIGURE ES-7



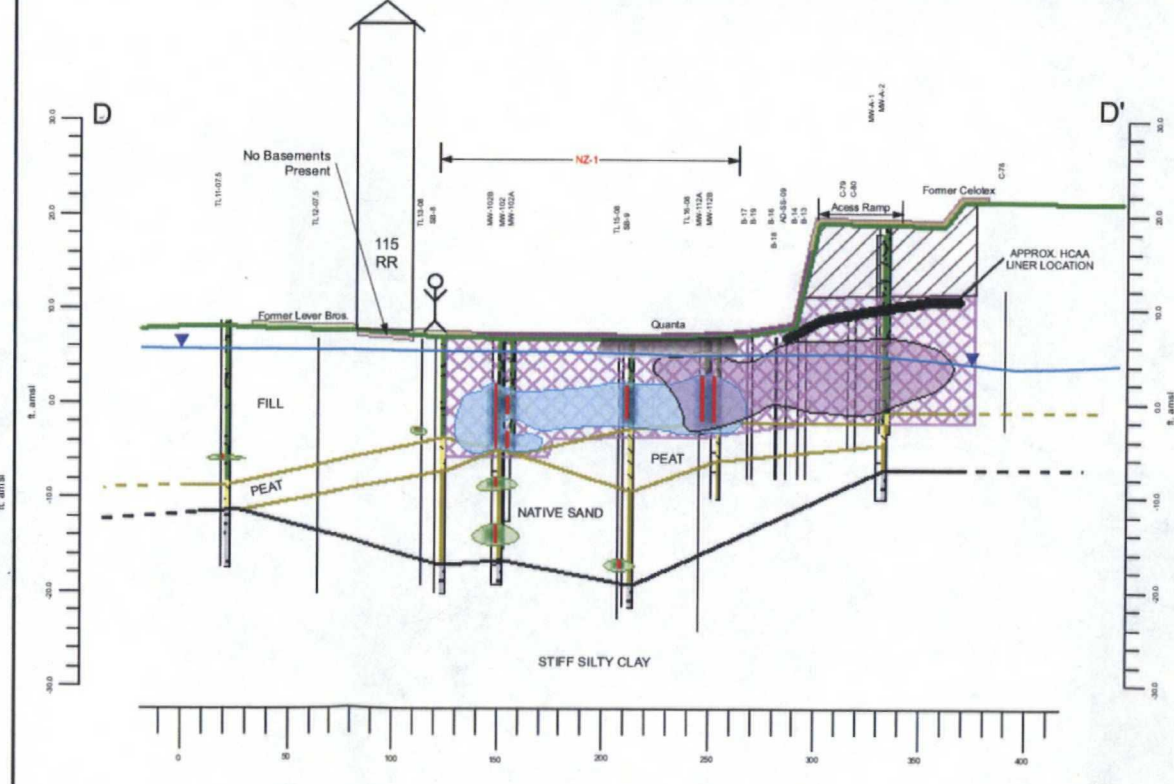
CROSS-SECTION A-A'



CROSS-SECTION B-B'

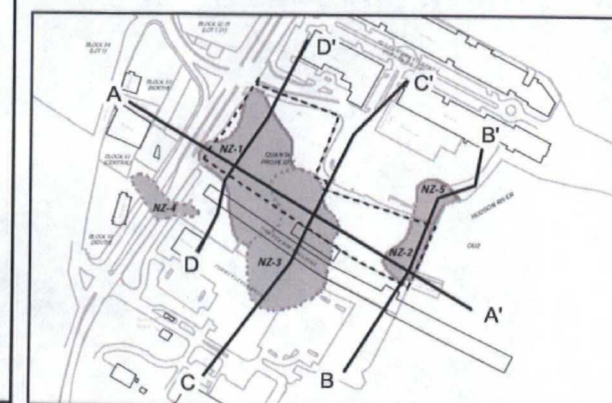
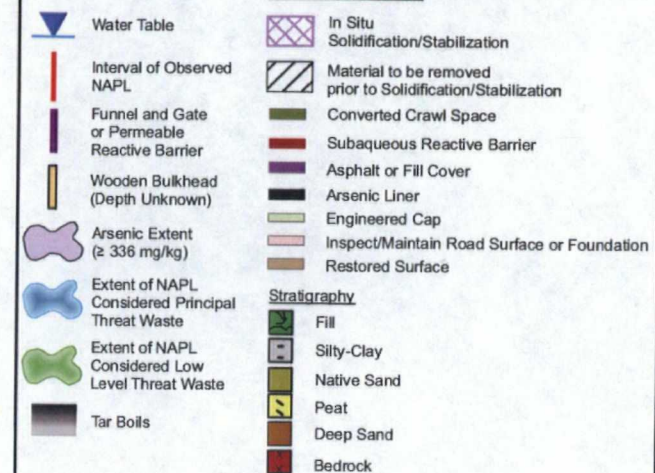


CROSS-SECTION C-C'



CROSS-SECTION D-D'

LEGEND



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL and final extent will be determined in the SRI.
2. Gradation of NAPL and tar boil shading is approximated for visual depiction.
3. Interval of observed NAPL based on boring logs and TarGOST responses.
4. Water table elevation depiction based on synoptic measurements taken in October 2006.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
amsl = above mean sea level
7. Nature of OU1/OU2 boundary will be determined in the SRI.
8. 115 River Road dimensions are estimated

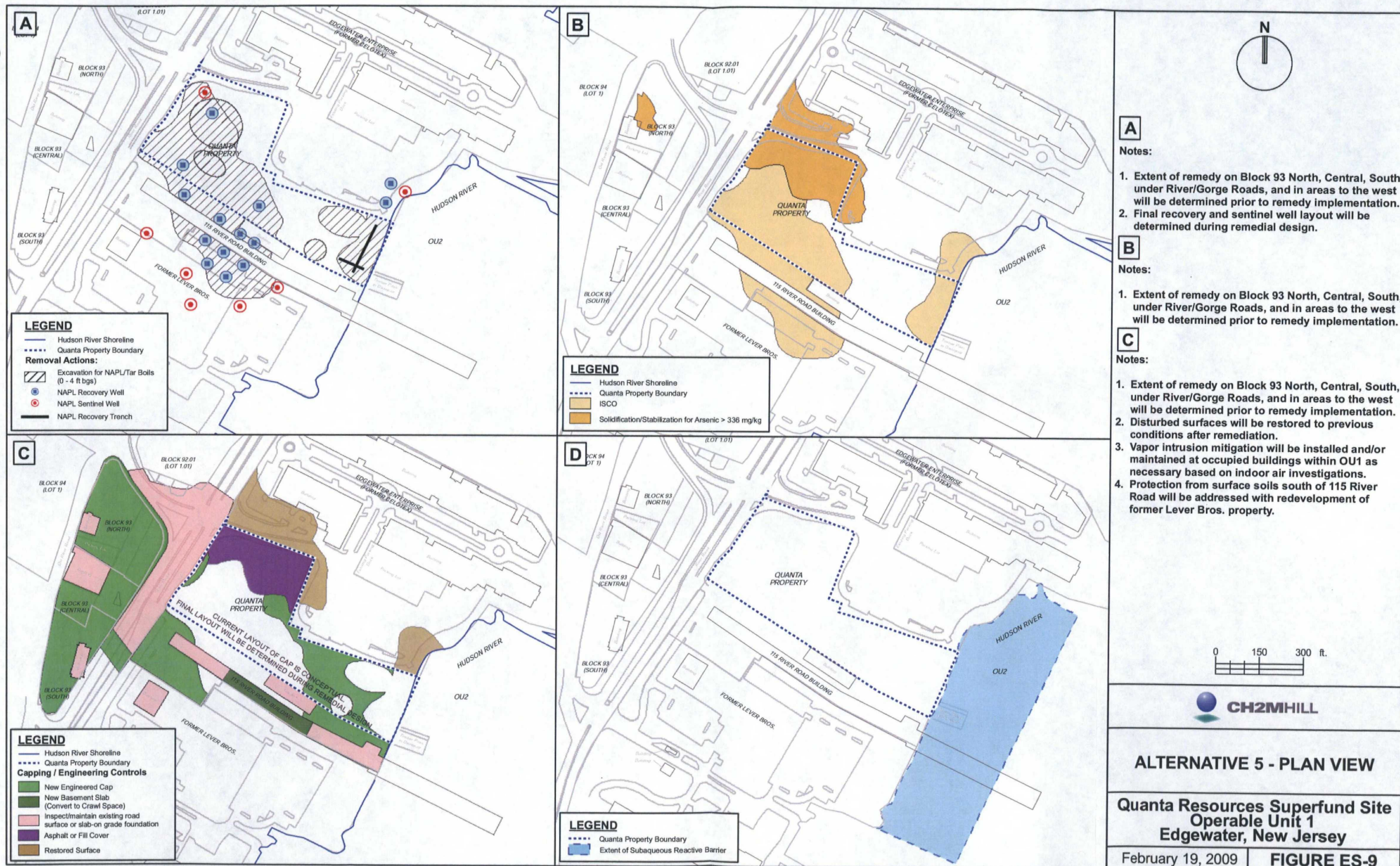


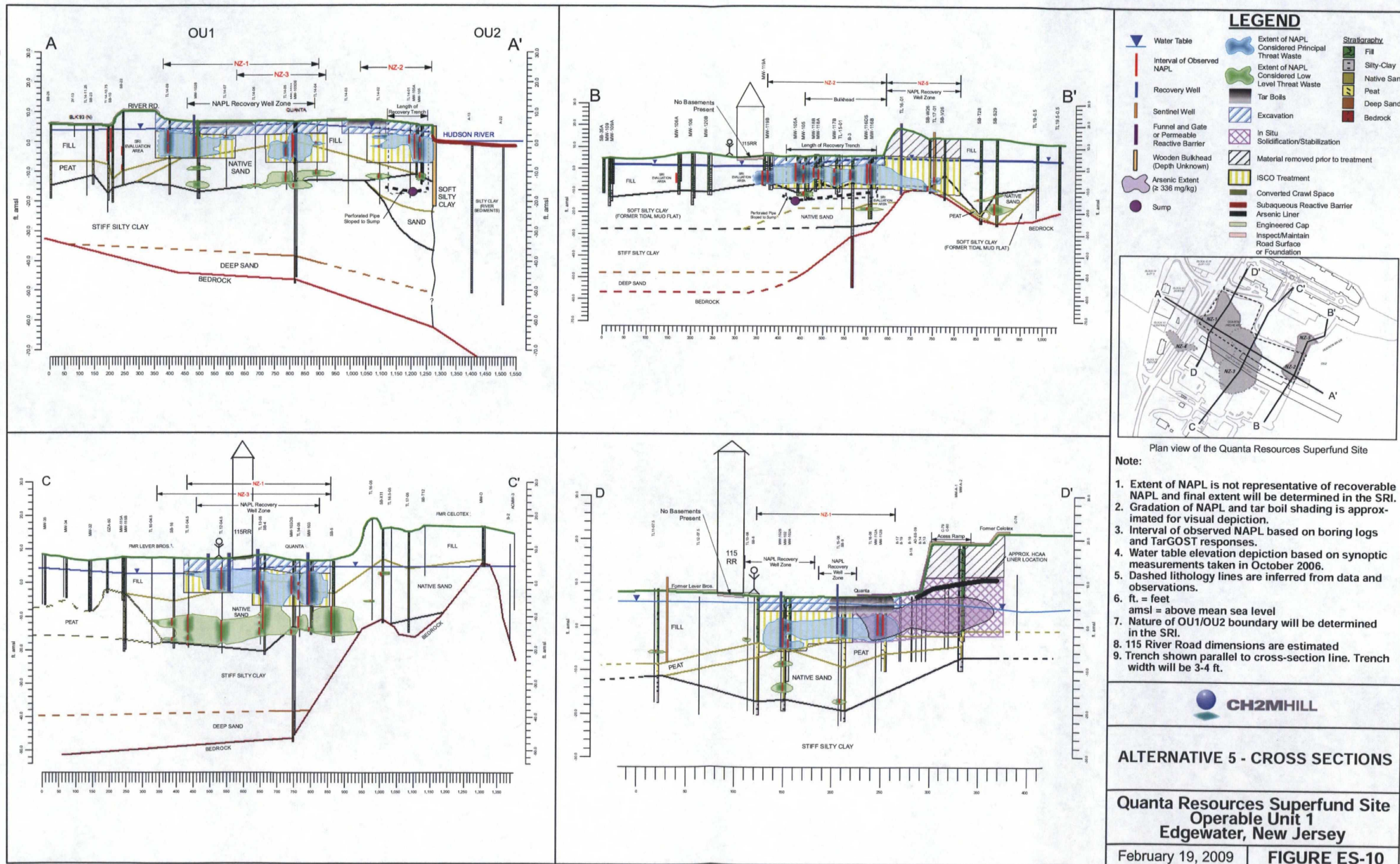
ALTERNATIVE 4 - CROSS SECTIONS

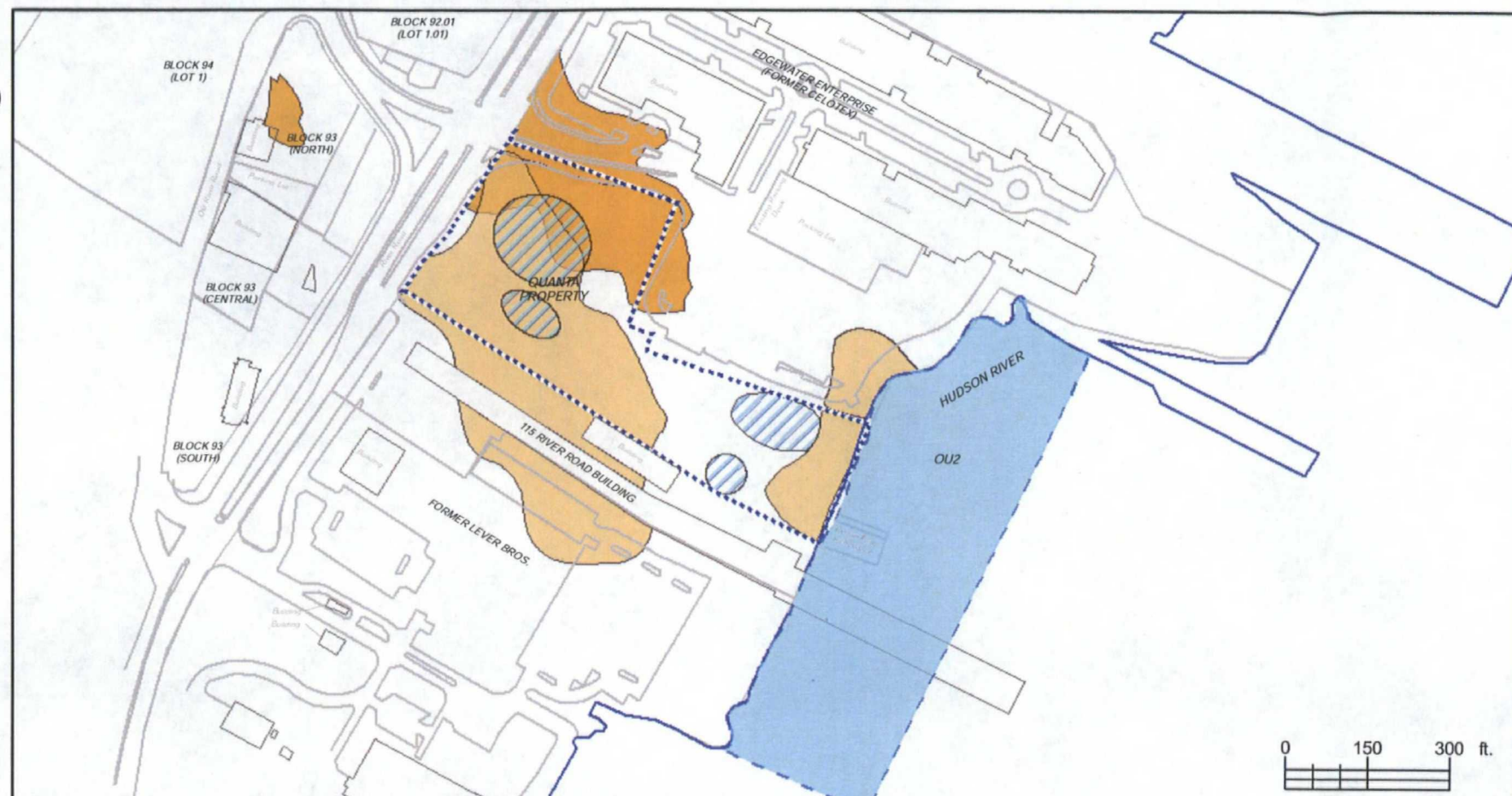
Quanta Resources Superfund Site
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FIGURE ES-8







LEGEND

- Quanta Property Boundary
- Hudson River Shoreline

Removal Actions:

- Excavation for NAPL/Tar Boils (0 - 4 ft bgs)
- Excavation for Arsenic > 336 mg/kg
- Extent of Subaqueous Reactive Barrier

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Final excavation depths will be determined during remedial design.



LEGEND

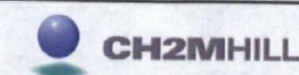
- Hudson River Shoreline
- Quanta Property Boundary

Capping/Engineering Controls

- Engineered Cap
- Inspect/maintain existing road surface or slab-on grade foundation
- New Engineered Cap
- New Basement Slab (Converted to Crawl Space)
- Extent of Subaqueous Reactive Barrier

Notes:

1. Disturbed surfaces will be restored to previous conditions after remediation.
2. Protection from surface soils south of 115 River Road will be addressed with redevelopment of former Lever Bros. property.
3. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
4. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
5. Required extent of new engineered cap as shown; final extent to be determined during remedial design.

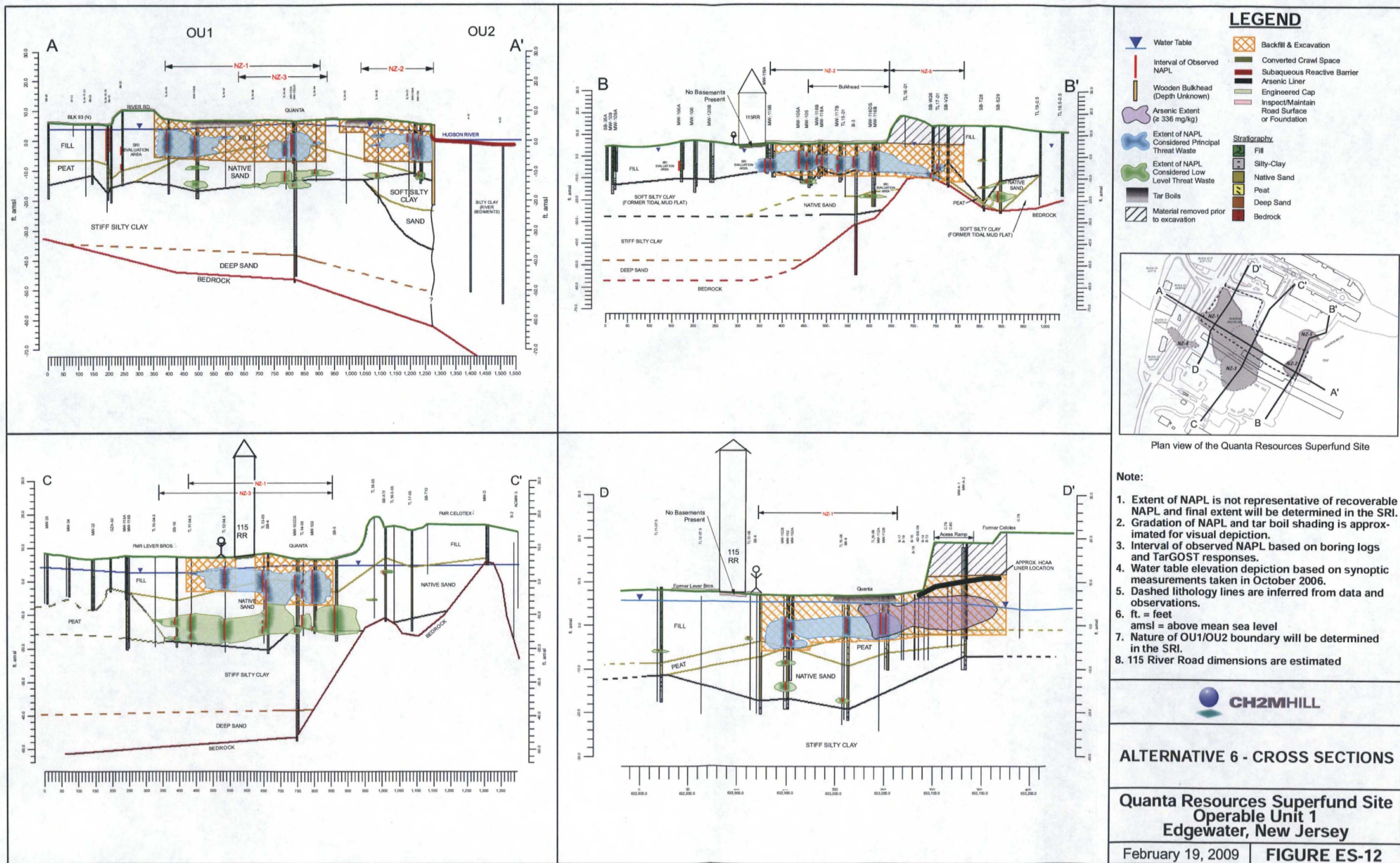


ALTERNATIVE 6 - PLAN VIEW

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE ES-11



each alternative will provide protection of human health and the environment but will require long-term maintenance of caps, institutional controls, a subaqueous reactive barrier, and vapor intrusion mitigation measures. The last two criteria, community acceptance and state acceptance, will be incorporated after a public comment period. Alternatives 2 through 6 all meet the two threshold criteria of overall protection of human health and the environment and compliance with ARARs, with the exception of drinking water ARARs for groundwater, as noted above.

Alternatives 2 through 6 satisfy the four "balancing" criteria of long-term effectiveness or permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; and implementability. Rough order-of-magnitude estimates are presented in Table ES-1 for each alternative for the fifth balancing criteria, cost. Estimates range from approximately \$30 million for Alternative 2 (containment) to \$90 million for Alternative 6 (excavation).

Finally, Table ES-1 summarizes how the alternatives comply with NJDEP regulations requiring the removal, treatment, or containment of product and why a technical impracticability waiver from the requirement to remediate groundwater to drinking water standards is appropriate at the site.

While each of the active alternatives satisfies the two threshold criteria, they satisfy the balancing criteria to different degrees, as presented in Table ES-2. On the basis of this evaluation, Alternative 4 (in situ solidification/stabilization) best satisfies the balancing criteria whereas Alternative 6 (excavation) is least favorable.

The following summarizes the performance of each of the alternatives with regard to the balancing criteria:

- Alternative 2 is least disruptive to the community, workers, and environment, and allows for the most rapid redevelopment of the Quanta property. However, this alternative would require the most restrictive institutional controls for future site land use due to the residual COCs that would remain onsite.
- Alternative 3 removes or solidifies/stabilizes principal threat waste and allows for relatively rapid redevelopment. However, this alternative would restrict future land use due to residual COCs that remain onsite. Excavated material must be transported to and disposed of at a landfill.
- Alternative 4 solidifies/stabilizes principal threat wastes and allows for relatively rapid redevelopment without requiring contaminated soil be moved to another location. However, large fill debris that will interfere with the mixing process would need to be removed prior to treatment. Treatability studies will be conducted to (1) determine the optimal reagent mix, (2) confirm corresponding cost-effectiveness under full-scale conditions, and (3) confirm compatibility with redevelopment objectives.
- Alternative 5 treats principal threat wastes; however, this alternative takes the longest period of time to implement; significantly delaying redevelopment. In addition, excavated contaminated soil must be transported to and disposed of at a landfill. If chemical oxidation were used, it would pose potential risks of NAPL mobilization and vapor intrusion.

who cares?

- Alternative 6 removes the most source material from the site and allows for relatively rapid redevelopment. It is also the least restrictive of future site land uses. However, it is the most disruptive to the site and community in the short term, and significant potential risks are posed by deep excavations adjacent to buildings and roadways. In addition, large volumes of contaminated soil must be transported to and disposed of at a landfill.

This FS evaluation also considered sustainability-related elements such as energy and carbon footprint reduction, waste generation reduction, timing, future land use potential, and offsite impacts in addition to the NCP criteria. In particular, due to its prime location, there is a significant benefit to the community in returning the site to productive use as soon as possible, and the alternatives are consistent with future redevelopment. In addition, the proposed groundwater component that is included in all alternatives is an energy-efficient solution that uses passive treatment, which reduces the amount of waste produced compared to other traditional approaches. Each alternative has the opportunity to include techniques during the remedial design that could enhance the overall sustainability of the alternative.

Conclusions and Next Steps

This FS report presents a range of alternatives developed to address the site ARARs, RAOs, and PRGs and the principal threat and low-level threat wastes identified for the site. This FS is consistent with EPA's expectations for development and evaluation of remedial alternatives and provides a range of alternatives that mitigate potential risk to human health and the environment. Once the SRI data have been evaluated, they will be used to update the alternatives presented in this FS.

The FS conclusions are the following:

- Although the data gaps currently being addressed in the SRI are not expected to materially affect the remedial technologies or remedial alternatives developed and evaluated in the FS, they could change the extent of the areas to which selected remedial actions will be applied. The evaluation of the SRI data will be completed prior to the final selection of a remedial alternative.
- A range of remedial alternatives has been developed to address the RAOs, PRGs, and principal-threat waste identified for the site.
- As part of the FS evaluation, it has been determined that the restoration of groundwater at the site is technically impracticable as a result of contaminant-related factors. Although a technical impracticability waiver for specific ARARs is requested, remedial alternatives are designed to prevent further migration of the plume and human exposure to the contaminated groundwater.

Following the submission of the final FS report, EPA will make available for public comment the FS report and proposed plan outlining the remedial alternatives and preferred alternative.

TABLE ES-1
Alternative Evaluation Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Alternative				
Evaluation Criteria		2—Containment	3—Containment, Excavation, and In Situ Solidification/Stabilization	4—In Situ Solidification/Stabilization	5—In Situ Solidification/Stabilization and Other In Situ Treatment	6—Excavation
Principal Threat Source Criteria	Components	NAPL recovery via wells/trenches (NZ-1, NZ-2, and NZ-5), capping, subaqueous reactive barrier (SRB), either a permeable reactive barrier (PRB) or a funnel and gate, institutional controls (ICs), and vapor intrusion mitigation.	Excavation to 4 feet bgs (tar boils, NZ-1, and NZ-2), NAPL recovery via wells/trenches (NZ-1, NZ-2, and NZ-5), in situ solidification/stabilization of HCAAs, capping, SRB, either PRB or funnel and gate, ICs, and vapor intrusion mitigation.	In situ solidification/stabilization of NAPL zones (tar boils, NZ-1, NZ-2, and NZ-5) and HCAAs, capping, SRB, ICs, and vapor intrusion mitigation.	Excavation to 4 feet bgs (tar boils, NZ-1, and NZ-2), NAPL recovery via wells/trenches (NZ-1, NZ-2, and NZ-5) followed by in situ solidification/stabilization of HCAAs, in situ treatment (e.g., by chemical oxidation) of NZ-1, NZ-2, and NZ-5, capping, SRB, ICs, and vapor intrusion mitigation.	Excavation of NAPL zones (tar boils, NZ-1, NZ-2, and NZ-5) and HCAAs, capping, SRB, ICs, and vapor intrusion mitigation.
	Mobility Flowable, "free-phase" NAPL	NAPL recovery and either a PRB or funnel and gate addresses potential NAPL migration to Hudson River.	NAPL recovery, either PRB or funnel and gate, and excavation address potential NAPL migration to Hudson River.	In situ solidification/stabilization mitigates potential migration of NAPL to Hudson River.	Excavation, NAPL recovery, in situ solidification/stabilization and other in situ treatment mitigates potential migration of NAPL to Hudson River.	Excavation mitigates potential migration of NAPL to Hudson River.
	Toxicity Poses excess lifetime direct contact risk at a level of 10^{-3} or greater for source near ground surface	Capping and ICs, including maintaining existing HCAA cap, eliminate direct contact pathway. NAPL recovery reduces potential for tar boil formation. PRB or funnel-and-gate protects ecological receptors from NAPL.	Excavation, capping, in situ solidification/stabilization of HCAAs, and ICs eliminate direct contact pathway. NAPL recovery reduces potential for tar boil formation. PRB or funnel-and-gate protects ecological receptors from NAPL.	In situ solidification/stabilization of NAPL and HCAAs reduces accessibility and leachability (and therefore toxicity). Capping and ICs are also provided.	In situ solidification/stabilization of HCAAs and in situ treatment of NAPL reduce accessibility and leachability (and therefore toxicity). Capping and ICs are also provided.	Excavation eliminates direct contact exposure pathway. Capping and ICs are also provided.
Other Source Considerations	Arsenic enabler	NAPL recovery increases potential for redox conditions to promote reduced arsenic solubility and increased attenuation of dissolved phase arsenic.	In situ solidification/stabilization for HCAA, thereby reducing potential for arsenic to leach to groundwater and increasing potential for redox conditions to promote attenuation of dissolved phase arsenic. NAPL recovery may change redox conditions, thereby further promoting attenuation of dissolved phase arsenic.	In situ solidification/stabilization for HCAA, thereby reducing potential for arsenic to leach to groundwater and increasing potential for redox conditions to promote attenuation of dissolved phase arsenic. In-situ solidification/stabilization of NAPL may change redox conditions, thereby further promoting attenuation of dissolved phase arsenic.	In situ solidification/stabilization treats HCAA, thereby reducing potential for arsenic to leach to groundwater and increasing potential for redox conditions to promote attenuation of dissolved phase arsenic. NAPL recovery and treatment may change redox conditions, thereby further promoting attenuation of dissolved phase arsenic.	Excavation removes HCAA.
	Groundwater source	NAPL recovery reduces source of PAHs to groundwater, thereby promoting attenuation. Residuals in soil, especially outside of treatment areas (such as NAPL, arsenic, and historic fill material), continue to serve as a source to groundwater.	Excavation and treatment (by in situ solidification/stabilization) reduces potential for arsenic and NAPL constituents to leach to groundwater. Residuals in soil, especially outside of treatment areas (such as NAPL, arsenic, and historic fill material), continue to serve as a source to groundwater.	In situ solidification/stabilization of NAPL and HCAA reduces potential for arsenic and PAHs to leach to groundwater and increases potential for redox conditions to promote attenuation of dissolved phase arsenic and PAHs. Residuals in soil (such as NAPL, arsenic, and historic fill material), especially outside of treatment areas, will continue to serve as a source to groundwater.	Excavation, recovery, and treatment of NAPL, in situ solidification/stabilization of HCAA reduces potential for arsenic and PAHs to leach to groundwater and increases potential for redox conditions to promote attenuation of dissolved phase arsenic and PAHs. Residuals in soil especially outside of treatment areas (such as NAPL, arsenic, and historic fill material) continue to serve as a source to groundwater.	Excavation reduces potential for arsenic and PAHs to leach to groundwater and increases potential for redox conditions to promote attenuation of dissolved phase arsenic and PAHs. Excavation of source material limits potential for material to serve as a source to groundwater. Residuals in unexcavated soil (such as NAPL, arsenic, and historic fill material) continue to serve as a source to groundwater.
	Surface water source	SRB addresses any remaining COCs in groundwater that are not addressed by attenuation.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
	Vapor source	Vapor intrusion mitigation installed in 115 River Road basements and in other occupied buildings if needed.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.

TABLE ES-1
Alternative Evaluation Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Alternative				
Evaluation Criteria		2—Containment	3—Containment, Excavation, and In Situ Solidification/Stabilization	4—In Situ Solidification/Stabilization	5—In Situ Solidification/Stabilization and Other In Situ Treatment	6—Excavation
NCP Evaluation Criteria ^a	Overall protection of human health and environment	NAPL recovery reduces TMV of NAPL principal threat waste. Capping and ICs minimize potential for exposure to low-level threat waste. PRB or funnel-and-gate protects Hudson River from NAPL migration; an SRB protects Hudson River from dissolved constituents in groundwater. Vapor intrusion mitigation protects against exposure to vapors. No exposure means no potential risk.	Same as Alternative 2, plus excavation further minimizes exposure to principal threat waste. No exposure means no potential risk.	In situ solidification/stabilization of NAPL zones and HCAAs reduces TMV of principal threat waste. Capping and ICs minimize potential for exposure to low level threat waste. Hudson River and vapor intrusion protection—same as for Alternative 2. No exposure means no potential risk.	NAPL recovery reduces TMV of NAPL principal threat waste. Excavation and in situ treatment of NAPL zones, in situ solidification/stabilization of HCAAs, capping, and ICs Potential for exposure to soil is minimized by. Hudson River and vapor intrusion protection—same as for Alternative 2. No exposure means no potential risk.	Excavation of NAPL zones and HCAAs reduces TMV of principal threat waste. Capping and ICs minimize potential for exposure to low level threat waste. Hudson River and vapor intrusion protection—same as for Alternative 2. No exposure means no potential risk.
	Compliance with ARARs	Capping reduces exposure to contaminants above cleanup criteria to achieve ARARs for soil. Groundwater is treated prior to surface water discharge in accordance with applicable ARARs. However, achievement of drinking water ARARs in inland groundwater is not feasible; therefore ICs used to prevent site groundwater from being used as drinking water, and a waiver of ARARs based on technical impracticability of groundwater restoration is necessary. Recovered NAPL is stored and disposed of in accordance with applicable ARARs. Vapor intrusion mitigation is used to achieve vapor ARARs.	Excavation, in situ solidification/stabilization, and capping reduce exposure to contaminants above cleanup criteria and achieve ARARs for soil. Other ARARs—same as Alternative 2.	In situ solidification/stabilization and capping reduce exposure to contaminants above cleanup criteria and achieve ARARs for soil. Other ARARs—same as Alternative 2.	Excavation, NAPL recovery, in situ treatment, and capping reduce exposure to contaminants above cleanup criteria and achieve ARARs for soil. Other ARARs—same as Alternative 2.	ARARs for soil are achieved reducing exposure to contaminants above cleanup criteria through excavation of NAPL zones and HCAAs. Other ARARs—same as Alternative 2.
	Long-term effectiveness and permanence	NAPL extraction permanently removes NAPL from site. Capping, ICs, and vapor intrusion mitigation are maintained indefinitely and provide reliable and long-term effectiveness in reducing potential risk associated with NAPL, soil, vapor, and groundwater.	Same as Alternative 2, plus excavation permanently removes NAPL from site.	Solidified soils, capping, ICs, and vapor intrusion mitigation provide reliable and long-term effectiveness in reducing potential risks associated with NAPL, soil, vapor, and groundwater.	Excavation and NAPL extraction permanently remove NAPL from site. In situ soil treatment, capping, ICs, and vapor intrusion mitigation provide reliable and long-term effectiveness in reducing potential risk associated with NAPL, soil, vapor, and groundwater.	Excavation, capping, ICs, and vapor intrusion mitigation provide reliable and long-term effectiveness in reducing potential risk associated with NAPL, soil, vapor, and groundwater.
	Reduction of toxicity, mobility, or volume	NAPL recovery reduces TMV. Some source material remains; however, capping, vapor intrusion mitigation, and ICs reduce exposure. SRB and either a PRB or funnel-and-gate protects Hudson River.	Same as Alternative 2, plus excavation reduces TMV.	In situ solidification/stabilization of NAPL zones and HCAAs reduces TMV. For remaining contamination and Hudson River—same as Alternative 2.	Excavation, NAPL recovery, in situ solidification/stabilization, and other in situ treatment reduce TMV. For remaining contamination and Hudson River—same as Alternative 2.	Excavation of NAPL zones and HCAAs reduces TMV. For remaining contamination and Hudson River—same as Alternative 2.
	Short-term effectiveness	Site-specific health and safety plans, engineering controls, and operation and maintenance plans mitigate potential risk to workers, community, and environment.	Same as Alternative 2. Plus in situ solidification/stabilization alters groundwater flow patterns, which could mobilize contaminants in untreated areas.	Same as Alternative 3.	Same as Alternative 4. If in situ chemical oxidation is used, there are additional potential risks of NAPL mobilization and vapor intrusion into occupied buildings.	Same as Alternative 2. Plus deep excavations adjacent to buildings and roadways present significant potential risks. Truck traffic, noise, and odors affect community.
	Implementability	Technically and administratively implementable assuming access is obtained and property owners concur with IC restrictions.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
	Present worth cost	\$31,850,00	\$56,810,00	\$37,380,00	\$79,980,000	\$96,510,000

TABLE ES-1
Alternative Evaluation Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Alternative				
Evaluation Criteria		2—Containment	3—Containment, Excavation, and In Situ Solidification/Stabilization	4—In Situ Solidification/Stabilization	5—In Situ Solidification/Stabilization and Other In Situ Treatment	6—Excavation
Specific Regulatory Considerations	Compliance with NJDEP 7:26E-6.1(d)	Complies with ARAR through removal of free-phase NAPL via extraction wells and trenches to extent practicable.	Complies with ARAR through excavation of NAPL zones and removal of free-phase NAPL via extraction wells and trenches to extent practicable.	Complies with ARAR through treatment of NAPL with in situ solidification/ stabilization.	Complies with ARAR through excavation, removal of NAPL via wells or trenches to extent practicable, and in situ treatment of NAPL.	Complies with ARAR through removal of NAPL through excavation of NAPL zones.
	Compliance with drinking water standards (i.e., technical impracticability waiver)	NAPL is removed to extent practicable in locations where significant risk reduction would result. Although contaminated groundwater is treated prior to being discharged to Hudson River, restoration of inland groundwater to drinking water standards is impracticable due to remaining contamination, historic fill, and offsite sources. A technical impracticability waiver based on technical impracticability of groundwater restoration is necessary.	Same as Alternative 2, except HCAAs are also solidified/stabilized in locations where significant risk reduction would result.	NAPL zones and HCAAs are treated in locations where significant risk reduction would result. For groundwater—same as Alternative 2.	NAPL is removed to extent practicable and NAPL zones and HCAAs are treated in locations where significant risk reduction would result. For groundwater—same as Alternative 2.	NAPL zones are excavated in locations where significant risk reduction would result. For groundwater—same as Alternative 2.

^a State and community acceptance are modifying criteria that are evaluated following public comment on the proposed plan and are used to modify the selection of the recommended alternative.

TABLE ES-2
Balancing Criteria Screening for Remedial Alternatives
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Balancing Criteria	Alternative				
	2—Containment	3—Containment, Excavation, and In Situ Solidification/Stabilization	4—In Situ Solidification/Stabilization	5—In Situ Solidification/Stabilization and Other In Situ Treatment	6—Excavation
1. Long-term effectiveness and permanence	1	4	6	6	4
2. Reduction of toxicity, mobility, and volume through treatment	1	4	8	8	4
3. Short-term effectiveness	10	6	6	4	1
4. Implementability	4	4	6	1	1
Total score without cost	16	18	26	19	10
5. Cost	8	6	8	4	1
Total score with cost^a	24	24	34	23	11

Note: The rankings used for this comparative analysis were determined based on the definitions provided below. The definitions are intended to provide a point of reference to the relative ranking selected.
^aBalancing criteria were weighted equally for the scoring; however, cost was shown for discussion purposes.

Scoring Definitions	Scoring									
	Best ← → Worst									
	10	9	8	7	6	5	4	3	2	1
1) Long-term effectiveness and permanence	No residual risk remaining from untreated waste or treatment residual; therefore, no long-term residual management controls are required.			—	Low residual risk remaining from untreated waste or treatment residual and high long-term reliability and degree of confidence in residual management controls.			—	Low long-term reliability and degree of confidence in residual management controls and significant risk if controls fail.	
2) Reduction of toxicity, mobility, and volume through treatment	Technology permanently and significantly reduces TMV of principal threats at the site including mass destruction of contaminants.			—	Technology permanently and significantly reduces TMV of principal threats at the site including nondestructive treatment of contaminants.			—	TMV would remain and exposure pathways would be mitigated.	
3) Short-term effectiveness	Low risk to the community, workers, and environment during construction and implementation.			—	High risk to the community, workers, or environment during construction and implementation that would be mitigated through engineering or administrative controls			—	High risk to the community, workers, and environment during construction and implementation that would be mitigated through engineering or administrative controls	
4) Implementability	Low anticipated number of difficulties or uncertainties associated with the construction, standard equipment or services are used, and technologies are readily available for full-scale use.			—	Higher anticipated number of difficulties or uncertainties associated with the construction that may lead to schedule delays, may require specialize equipment or services, or limited vendor availability.			—	Highest anticipated number of difficulties or uncertainties associated with the construction that may lead to schedule delays, may require specialize equipment or services, and limited vendor availability.	
5) Cost (\$millions)	< 20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100

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4-20	Conceptual Extent of Subaqueous Reactive Barrier – Alternatives 4, 5, and 6
4-21	Excavation and NAPL Recovery – Alternative 5
4-22	In Situ Solidification/Stabilization and Other In Situ Treatment – Alternative 5
4-23	Alternative 5 – Cross Section A-A'
4-24	Alternative 5 – Cross Section B-B'
4-25	Alternative 5 – Cross Section C-C'
4-26	Alternative 5 – Cross Section D-D'
4-27	Capping/Engineering Controls – Alternative 5
4-28	Excavation – Alternative 6
4-29	Alternative 6 – Cross Section A-A'
4-30	Alternative 6 – Cross Section B-B'
4-31	Alternative 6 – Cross Section C-C'
4-32	Alternative 6 – Cross Section D-D'
4-33	Capping/Engineering Controls – Alternative 6

Abbreviations and Acronyms

µg/L	micrograms per liter
ARAR	applicable or relevant and appropriate requirement
AOC	Administrative Order on Consent
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COC	constituent of concern
COI	constituent of interest
cSt	centistoke
DNAPL	dense non-aqueous phase liquid
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HCAA	high-concentration arsenic area
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ISCO	in situ chemical oxidation
LNAPL	light non-aqueous phase liquid
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
NAPL	non-aqueous phase liquid
NCP	National Contingency Plan
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
NPL	National Priorities List
NJSA	New Jersey Statutes Annotated
NZ	NAPL zone
OU	operable unit
PAH	polycyclic aromatic hydrocarbon

PCB	polychlorinated biphenyl
POTW	publicly owned treatment works
PPE	personal protective equipment
PRB	permeable reactive barrier
PRG	preliminary remediation goal
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	record of decision
SRB	subaqueous reactive barrier
SLERA	screening-level ecological risk assessment
SRI	supplemental remedial investigation
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TarGOST®	Tar-Specific, Green Optical Screening Tool (Dakota Technologies, Inc.)
TBC	to be considered
TCLP	Toxicity Characteristic Leaching Procedure
TI	technical impracticability
TMV	toxicity, mobility, or volume
VOC	volatile organic compound

SECTION 1

Introduction

This draft feasibility study (FS) report for Operable Unit (OU) 1 of the Quanta Resources Superfund Site,³ located in Edgewater, New Jersey (Figure 1-1), has been prepared in accordance with the requirements of the U.S. Environmental Protection Agency (EPA) Administrative Order on Consent (AOC) II-Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)-2003-2012 for the Uplands Area, OU1 (EPA, 2003). The site is adjacent to the Hudson River, in northeastern New Jersey. Surface water and sediment in the Hudson River are considered OU2 and are being investigated pursuant to a separate EPA AOC. The site was listed on the National Priorities List (NPL) on September 9, 2002. In a manner consistent with the OU1 AOC, the site characterization, remedial evaluation, and selection process are being conducted pursuant to the EPA National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations [CFR] 300), *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988a), and other relevant guidance, stated in this report and listed in Section 6.

1.1 Purpose

This report documents the development and evaluation of remedial action alternatives for OU1. The EPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP), and with public input, will use this information to select a remedial action alternative in its record of decision (ROD) in accordance with 40 CFR 300.

The criteria for remedy selections under CERCLA establish the following five principal requirements for the selection of a remedy:

- Protect human health and the environment
- Comply with applicable or relevant and appropriate requirements (ARARs) of federal and state environmental laws within a reasonable timeframe
- Be cost-effective
- Use permanent solutions and alternative treatment technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces contaminant toxicity, mobility, or volume (TMV)

The goal of the remedy selection process, as stated in 40 CFR 300.430 (a)(1)(i), is to select remedies that protect human health and the environment, that maintain protection over

³ As defined in the Administrative Order on Consent (AOC) II-CERCLA-2003-2012, the Quanta Resources Superfund Site includes the former Quanta Resources property, located on River Road in Edgewater, New Jersey, and any areas where contamination from the property has come to be located. The current Quanta property refers to Block 95, Lot 1, as defined on the Borough of Edgewater, New Jersey, tax map.

time, and that minimize untreated waste. The National Contingency Plan (NCP) describes EPA's six expectations for development of remedial alternatives consistent with 40 CFR 300.430(a)(1)(iii)(A-F):

- Use treatment to address the principal threats posed by a site, wherever practicable
- Use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable
- Use a combination of methods, as appropriate, to achieve protection of human health and the environment
- Use institutional controls, such as water use and deed restrictions, to supplement engineering controls as appropriate, for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants or contaminants
- Consider using innovative technology when such technology offers the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance, than demonstrated technologies
- Return usable groundwaters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site

OSWER Directive No. 9355.7-04 (EPA, 1995a) provides additional information for considering current and future land use during development and selection of remedial alternatives. In addition, EPA has developed nine criteria for evaluating remedial alternatives to ensure that all important considerations are factored into remedy selection decisions. The nine-criterion analysis comprises two steps: (1) an individual evaluation of each alternative with respect to each criterion, and (2) a comparison of options to determine the relative performance of the alternatives through an evaluation of relative advantages and disadvantages. This analysis is provided in Section 5.

As described in EPA (1988a) guidance and in 40 CFR 300, the FS consists of the development and screening of remedial alternatives, and the detailed analysis of selected alternatives.

The following steps were used in developing the remedial alternatives for the site:

1. Identify ARARs
2. Develop remedial action objectives (RAOs)
3. Define remedial action goals, including the following:
 - Developing quantitative preliminary remediation goals (PRGs) using chemical-specific ARARs and human health- and ecological-based risk levels
 - Identifying areas of constituents exceeding PRGs
4. Develop general response actions
5. Identify and screen technologies (including innovative technologies)
6. Identify and evaluate technology process options
7. Assemble remaining process options into remedial alternatives
8. Evaluate the remedial alternatives in accordance with the 40 CFR 300



Map Source:
 Central Park, New York – New Jersey
 United States Geological Survey
 7.5 Minute Quadrangle

Topography and photogrammetric
 methods from aerial photographs
 taken in 1954 and planetable
 surveys in 1956. Field checked in
 1966. Revised in 1979 from aerial
 photographs taken in 1977.



CH2MHILL

Study Area Location Map

**Quanta Resources Superfund Site
 Operable Unit 1
 Edgewater, New Jersey**

August 14, 2007

FIGURE 1-1

1.2 Report Organization

This report consists of six sections. Section 1 introduces the FS; summarizes background information, such as site physical description, site geology and hydrogeology, nature and extent of contamination, fate and transport, and summary of human health and ecological risks; and presents an overall conceptual site model for OU1.

The ARARs, RAOs, and PRGs that are intended to adequately protect human health and the environment are discussed in Section 2. Chemical-specific PRGs were developed for soil and groundwater based on the potential risk associated with the various concentrations of constituents in those media, and ARARs.

Section 3 presents the developed general response actions that address remedial action goals and introduces the identification and screening of the technology types and process options. Remedial technologies were screened to reduce the number of technologies considered in the detailed alternatives.

Section 4 presents the assembly of the remaining technologies into remedial action alternatives that achieve some or all of the remedial action goals, and provide a range of levels of remediation and a corresponding range of costs.

A detailed analysis of these remedial alternatives retained after the initial screening is presented in Section 5.

Section 6 includes references used during the preparation of this FS.

1.3 Definitions

Definitions that will be used throughout this document include the following.

Quanta Property. The land portion of Block 95, Lot 1 (which is between River Road and a wooden bulkhead at the edge of the Hudson River), in Edgewater, New Jersey.

Quanta Resources Superfund Site. As defined in the AOC II-CERCLA-2003-2012, the Quanta Resources Superfund Site includes “the former Quanta Resources Site and any areas where contamination from the Site has come to be located.” The site consists of two operable units, OU1 and OU2.

NAPL. Non-aqueous phase liquid, or “product.” NAPL can exist as a single chemical component or as a mixture, and it can occur in soils in free-phase or residual states. Residual NAPL is defined as being immobile when soil capillary forces are greater than gravity and hydraulic forces (Cohen and Mercer, 1993). Free-phase NAPL moves under the force of gravity and hydraulic forces. In this report, the term “NAPL” refers to both free-phase and residual states, unless otherwise noted.

LNAPL. Light non-aqueous phase liquid. LNAPL has a density less than 1.0.

DNAPL. Dense non-aqueous phase liquid. DNAPL has a density greater than 1.0.

Coal Tar. Material characterized as a complex mixture of compounds, typically complex hydrocarbons and other byproducts from former manufactured gas plant operations (Hayes

et al., 1996; EPA, 2000). At the site, coal tar was delivered to the former Barrett property for use by the Barrett Company Shadyside Plant ⁴ for production of roofing paper and other materials.

Tar Boils. Solid, black, soft-to-stiff, semiplastic-to-plastic tar in the near surface vadose zone that has been observed to seep upward to the ground surface through cracks in soil or pavement on very hot days (at or around 90°F). Once the tar reaches the surface, it either forms a bubble or spreads out laterally in thin layers within the preexisting, hardened tar (from past heating events).

COI. Constituent of interest. A constituent present at concentrations exceeding one or more screening criteria. COIs were identified in the remedial investigation (RI) report (CH2M HILL, 2008a) by screening analytical results against the lowest available soil and groundwater screening criteria from among the 2004 EPA Region 9 PRGs (residential soil, industrial soil, and groundwater), proposed New Jersey soil cleanup criteria (residential, nonresidential, and impact-to-groundwater) (New Jersey Administrative Code [NJAC] 7-26D),⁵ and promulgated New Jersey groundwater quality criteria (or interim generic values (NJAC 7:9-6).

COC. Constituent of concern. A constituent present at concentrations exceeding calculated acceptable risk ranges in the ecological or human health risk assessments.

Source Material. Material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of constituents to groundwater, to surface water, or to air, or act as a source for direct exposure (EPA, 1991).

High-Concentration Arsenic Area. The high-concentration arsenic area (HCAA) is defined by the extent of reddish-purple soils or where concentrations of arsenic in soil exceed the risk-based concentration of 336 mg/kg. At the Quanta property, this is based on visual observations and analytical data associated with historical investigations, as well as RI soil investigations. For the former Celotex property, the extent of the HCAA is depicted as the extent of the impermeable arsenic liner, which was designed and built to cover concentrations of arsenic in soil in excess of 1,000 mg/kg.

Principal Threat Waste. Source material considered highly toxic or highly mobile that generally cannot be reliably contained and that would present a significant potential risk to human health or the environment should exposure occur (EPA, 1991). Highly mobile source material would consist of unimpeded low-viscosity liquid, whereas low-mobility material could consist of either trapped low-viscosity liquid or high-viscosity liquid or solids. Highly toxic source material represents a significant potential risk based on the characteristics of the material and based on the exposure potential of the material (e.g., greater than 10⁻³ excess lifetime cancer risk or ELCR).

Low-Level Threat Waste. Source material that generally can be reliably contained and that would present only a low-level potential risk in the event of release. They include source

⁴ The town of Edgewater was formerly known as Shadyside, New Jersey.

⁵ Data in the RI Report were screened against the NJDEP proposed soil cleanup criteria available in March 2007. Soil standards were promulgated on June 2, 2008, and were used to develop remedial goals for OU1, as discussed in Section 2 of this FS Report.

materials that exhibit low toxicity, low mobility in the environment, or are near health-based levels.⁶

1.4 Site Setting and Background

OU1 consists of the current Quanta property, portions of the former Celotex property to the north, the 115 River Road property to the south, portions of the former Lever Brothers property further south, a portion of River and Gorge roads to the west, and portions of Block 93 North, Central, and South, also to the west (Figure 1-2).⁷ The total land area of OU1 encompasses approximately 23 acres. A tidally influenced mud flat or marsh associated with the Hudson River borders OU1 immediately to the east of the wooden bulkhead. These river sediments consist of silt to clayey silt greater than 50 feet thick immediately east of the bulkhead. Sediment and surface water are being addressed under a separate AOC for OU2 of the site.

Prior to the mid-1800s, the site and surrounding areas were tidal marshlands associated with the Hudson River. Development of rail lines and industry along the banks of the Hudson River prompted the systematic filling of these marshlands. Fill material during this timeframe is known to have contained coal, coal ash, wood ash, cinder, and slag. This fill material contains varying concentrations of polycyclic aromatic hydrocarbons (PAHs) and heavy metals in concentrations that often exceed regulatory soil cleanup criteria and contribute to the presence of constituents in groundwater. From approximately 1872 to 1971, a large portion of the site was used to process coal tar and to produce paving and roofing materials. The former Celotex property has been the site of a chemical plant, a gypsum company, a vacuum truck company, and a metal reclaiming/refinishing plant. The chemical plant, General Chemical Company, operated on the southern portion of the property from at least 1900 until 1957. The chemical plant was used to produce acids, alums, sodium compounds, and sulfuric acid (Parsons, 2005). In 1974, a portion of the site was reoccupied and leased for oil recycling, which continued until NJDEP prohibited facility operations in 1981. Afterward, aboveground and underground storage tanks were removed, and the site has remained vacant since.

1.5 Site Geology, Hydrogeology, and Hydrology

1.5.1 Geology

Soil impacted by former site operations consists predominantly of fill material and deposits of native sand and peat in contact with shallow groundwater. These units are underlain by a silty-clay confining layer at a depth of approximately 10 to 30 feet below ground surface (bgs), ranging in thickness from 10 to 25 feet. A confined, water-bearing "deep sand" unit lies between the aquitard (confining unit) and the bedrock surface. This deeper sand unit is approximately 7 to 25 feet thick, extending laterally to near the edge of the Hudson River and vertically to the bedrock surface, which ranges in depth from 8.5 to 60 feet bgs.

⁶ OSWER Directive 9380.3-06FS.

⁷ Further delineation of OU1 in the vicinity of Block 93 has been proposed in the "Final Remedial Investigation/Feasibility Study Work Plan Addendum No. 4 for a Supplemental Remedial Investigation" (CH2M HILL, 2008b), the results of which will be evaluated prior to remedy implementation.

1.5.2 Hydrogeology

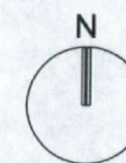
The direction of the shallow unconfined groundwater flow is generally to the east and south, with an area of radial flow on the Quanta property. Evaluation of groundwater elevation data indicates that the direction of the shallow groundwater is predominately to the southeast, under an average hydraulic gradient of 0.0068 foot/foot during low-tide conditions and 0.0066 foot/foot during high-tide conditions. Flow direction remains consistent between daily tidal events (low and high tides); however, the hydraulic gradient is slightly steeper during low-tide conditions. A tidal response has been observed in monitoring wells adjacent to the Hudson River north and south of the area of the wooden bulkhead on the Quanta property. Groundwater within the deep sand hydrostratigraphic unit flows more uniformly toward the east-southeast. Groundwater elevations in the deep sand hydrostratigraphic unit are influenced more by tidal conditions than are those in the shallow hydrostratigraphic unit.

Tidal influences on the shallow and deep sand hydrostratigraphic units decrease westward from the Hudson River. Typically, variance in groundwater elevations in monitoring wells at the northwestern portion of the Quanta property are small compared to those in monitoring wells on the southeastern portion of the property. Wells along the shoreline of the Quanta property do not appear to be nearly as tidally influenced as those along the river to the south at the 115 River Road and former Lever Brothers properties, or those wells to the north at the former Celotex property.

This lack of response is a result of the presence of the wooden bulkhead in this area, which appears to be acting as a hydraulic barrier between surface water and shallow groundwater. Review of the potentiometric contours near the bulkhead reveals that shallow groundwater hydraulic heads are building up behind this barrier. The difference in head measured in surface water versus the head measured in the shallow groundwater wells adjacent to the bulkhead, as well as the lack of tidal response in these monitoring wells, suggests a limited hydraulic connection between groundwater west of the bulkhead and surface water at OU2. The presence and nature of the connection between OU1 and OU2 will be refined on the basis of the results of the supplemental remedial investigation (SRI). Groundwater flow direction at the site remains consistent between daily tidal events (low and high tides); however, the hydraulic gradient is slightly steeper during low-tide conditions due to the tidal response in monitoring wells adjacent to the Hudson River (hydraulically downgradient portion of the site).

The radial groundwater flow pattern in shallow unconfined groundwater is the result of localized recharge associated with low-lying unpaved areas in the central portion of the Quanta property and the presence of the wooden bulkhead, which is impeding groundwater flow to the Hudson River from OU1. The effect of this barrier is evidenced in the dampened tidal influences and consistently higher hydraulic heads observed at monitoring wells behind the bulkhead compared to those measured in monitoring wells to the north and south. The average hydraulic gradients at low tide are 0.0007 foot/foot, 0.0014 foot/foot, and 0.0029 foot/foot, to the west, north, and east, respectively.

South of the site, an area of groundwater convergence has been observed consistently near the central to northern portion of the former Lever Brothers property. At this location, shallow unconfined groundwater from the central portions of the former Lever Brothers

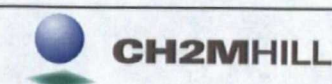
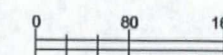


LEGEND

..... APPROXIMATE PROPERTY BOUNDARIES

Notes:

- 1.) Source of Aerial Photograph: Aerographics Corporation, 2005. Pic No. 20602382S, Frame No. 216. Scale: 1:3,100, 1 inch = 258 feet. April 16.
- 2.) Approximate property boundaries taken from most recent Bergen County Tax Maps.
- 3.) For purposes of this figure property lines are not extended into the Hudson River.



PROPERTY LOCATION MAP WITH AERIAL PHOTOGRAPH

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

November 1, 2007

FIGURE 1-2

flows to the northeast and converges with groundwater flowing from the Quanta property. This interpretation has been confirmed by data collected as part of environmental investigations at the former Lever Brothers property (GZA, 2008).

Hydraulic heads in the deep sand unit are consistently higher than those observed in collocated wells screened at the base of the unconfined shallow groundwater zone. The vertical hydraulic gradients measured between the unconfined and deep sand units remain upward during high- and low-tide conditions and confirm that the two units are not connected hydraulically. The reported hydraulic conductivity values for samples collected from the silty clay interval between the two sand units ranged from 4.06×10^{-7} cm/s to 8.19×10^{-8} cm/s. The low-permeability values of these undisturbed samples support the classification of the silty-clay interval as an aquitard.

1.5.3 Hydrology

Although OU2 is being investigated pursuant to a separate AOC, mitigating potential risk posed by any potential constituent flux from groundwater (OU1) to surface water (OU2) is a critical element of remedial goal development for OU1. One of the objectives of CH2M HILL (2008b) was to “characterize groundwater flow paths and distribution and fate and transport of coal tar constituents (volatile organic compounds [VOCs] and PAHS) and arsenic across the groundwater-surface water transition zone(s) between OU1 and OU2.” The results of the investigation will be evaluated prior to final remedy selection and implementation; however, potential migration of constituents from OU1 to OU2 across the groundwater-surface water transition zone is addressed in this FS.

1.6 Conceptual Site Model

1.6.1 Sources

Sources of site-related constituents were identified and characterized during the OU1 RI (CH2M HILL, 2008a). The primary sources of these constituents are no longer present except for material that may be contained within piping buried on the Quanta property. Historical operations included coal-tar-processing operations and, subsequently, oil-recycling operations. A former acid plant, located on the northern portion of the Quanta property and the southern portion of the former Celotex property, contributed to the presence of oxidized pyritic ore remnants in soil which is one source of arsenic at the Site.

As a result of historical site activities, secondary sources remain at the site today in the form of NAPL, solid tar, unburned or partially burned pyrite ore, and soil containing PAHs, non-PAH semivolatile organic compounds (SVOCs), aromatic VOCs, and other constituents. Although pipes of various sizes and construction materials exist in the subsurface at OU1, none of the pipes investigated appear to be acting as preferential pathways for the offsite migration of NAPL or other constituents of concern (COCs) (CH2M HILL, 2008a).

Before 1985, when initial removal actions were proposed, the property had 61 aboveground storage tanks, an unknown number of underground storage tanks, and underground piping. The total storage capacity of the tanks was over 9 million gallons of “oil, tar, asphalt, sludge, process water, and other unknown liquids” (EPA, 2003).

Additional secondary sources of groundwater and soil constituents unrelated to OU1 but within its extent⁸ include the following:

- Historical filling throughout this portion of Edgewater, New Jersey (NJDEP, 2004a)
- Identified AOCs at the former Lever Brothers property (Langan, 2003, 2004)
- Upgradient source of chlorinated solvents impacting groundwater within the confined deep sand unit
- Polychlorinated biphenyls (PCBs) in soil at the former Celotex and former Lever Brothers properties

1.6.2 Nature and Extent

To develop a comprehensive understanding of the nature and extent of site-related constituents and to define the boundaries of OU1, the RI report (CH2M HILL, 2008a) compiled data from 3,600 soil analyses (Figure 1-3), 57 groundwater-monitoring locations (Figure 1-4), NAPL fingerprinting and physical analyses, TarGOST® coal tar delineation, soil vapor analyses, indoor/outdoor air analyses, and building surveys. The extent of NAPL was defined on the basis of this comprehensive data set, and specific COIs were developed for soil and groundwater. COIs were identified by screening analytical results against the lowest available soil- and groundwater-screening criteria from among the EPA (2004) Region 9 PRGs (residential soil, industrial soil, and groundwater), proposed New Jersey soil cleanup criteria (residential, nonresidential, and impact to groundwater) (NJAC 7-26D),⁹ and promulgated New Jersey groundwater quality criteria or interim generic values (NJAC 7:9-6).

OU1 is well understood, and appropriate data evaluations have been performed to support remedy decisions. To the west, the definitive extent of the presence of site-related material will be determined as part of the implementation of the “Final Remedial Investigation/Feasibility Study Work Plan Addendum No. 4 for a Supplemental Remedial Investigation,” submitted to EPA on July 31, 2008 (CH2M HILL, 2008b). Although the conditions in these areas are not expected to materially affect the remedial technologies or remedial alternatives developed and evaluated in the FS, they could change the extent of the areas to which selected remedial actions will be applied.

Nature and Extent of NAPL and Solid Tar


The location, nature, and extent of free and residual NAPL at OU1 have been characterized using analytical data, field observations, and TarGOST® (Tar-Specific, Green Optical Screening Tool; Dakota Technologies, Inc.). The extent of solid tar has been defined through field observations. Residual- and free-phase NAPL occur in shallow soils in discrete areas above and on top of the silty-clay confining layer. The presence of coal tar constituents


⁸ COIs present within the extent of OU1 as a result of these non-site-related sources are not specifically targeted by the remedial alternatives evaluated in this FS, but may be mitigated by proposed actions if they are implemented in the same location.

⁹ Data in the RI report were screened against the NJDEP proposed soil cleanup criteria available in March 2007. Soil standards were promulgated on June 2, 2008, and were used to develop remedial goals for OU1, as discussed in Section 2 of this FS report.



LEGEND

SB-116B
 LOCATION OF SOIL SAMPLE(S) COLLECTED AS PART OF QUANTA RESOURCES SUPERFUND SITE INVESTIGATIONS

SB-S26
 LOCATION OF SOIL SAMPLE(S) COLLECTED AS PART OF INVESTIGATIONS AT OTHER PROPERTIES

----- QUANTA PROPERTY BOUNDARY

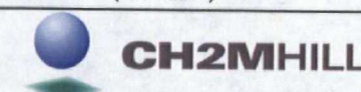
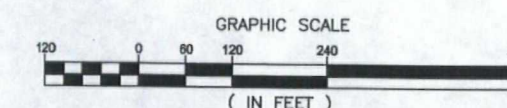
— HUDSON RIVER SHORELINE

NOTES:

1. Depiction of other properties on this figure is for comparative purposes and does not necessarily suggest that Site-related constituents have migrated there.
2. Soil sampling locations well to the north and south of the Site were evaluated in order to confirm the lateral extents of Site-related constituents. The use of these data in evaluations performed at the Quanta Resources Superfund Site does not necessarily indicate that impacts are related to the Quanta Resources Superfund Site.
3. The representativeness of historic data collected prior to 2003 to the north of the Quanta property is questionable due to redevelopment and remedial activities that have taken place at these properties (Edgewater Enterprises and Edgewater Theaters, Inc.).

Basemap Sources:

- a.) Boundary and topographic survey of Block 95, Lot 1 and Block 93, Lots 1, 2, and 3 performed by Vargo Associates in September 2005 and updated as recently as June 2007.
- b.) Borough of Edgewater Tax Map - November, 1959.
- c.) Coal Tar Engineering Design Report (Environ, July 2005).
- d.) Site Investigation Report, Part 4 (Langan, May 2004) for the former Lever Bros. Property.

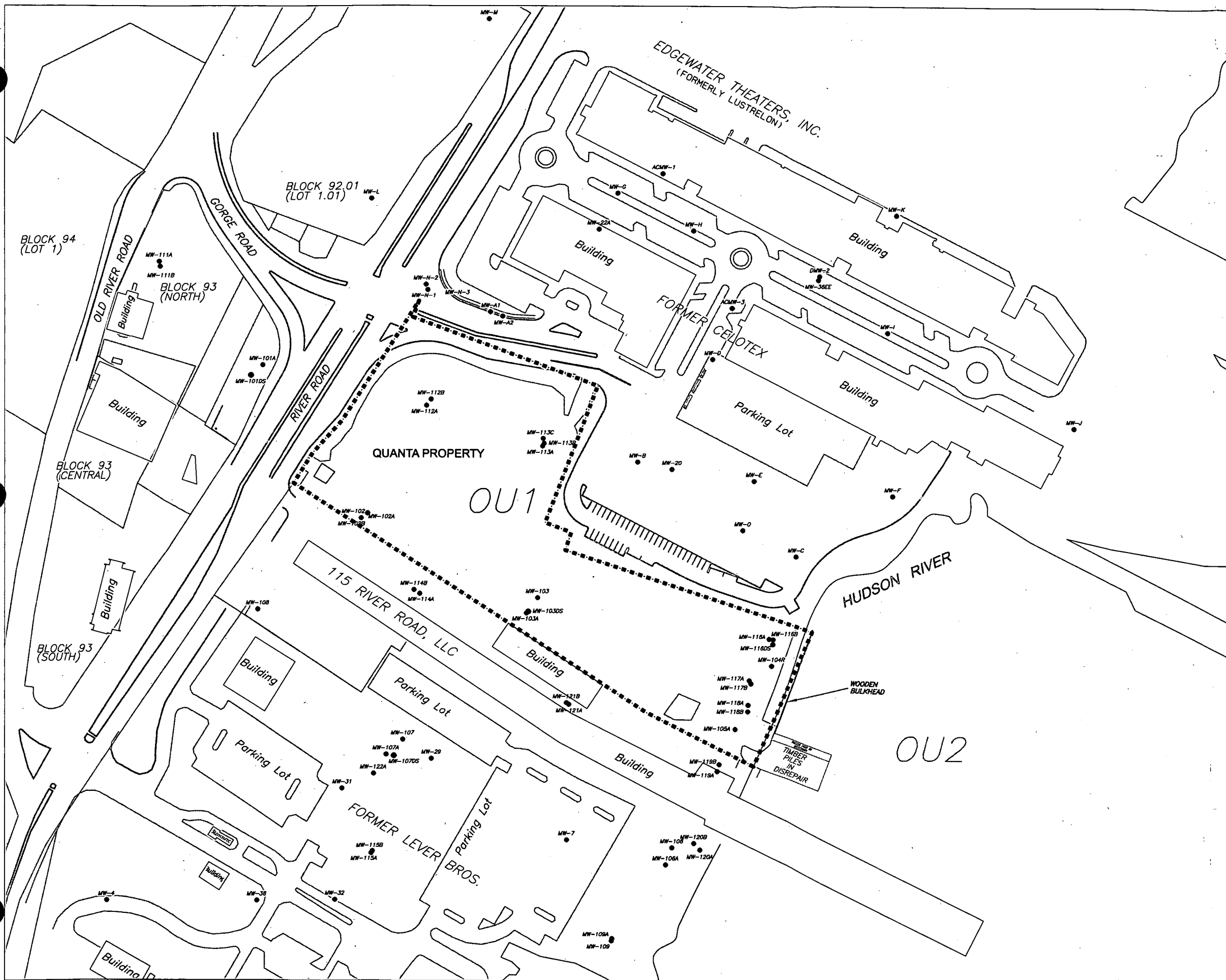


REMEDIAL INVESTIGATION SOIL SAMPLE LOCATIONS

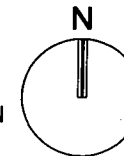
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

November 6, 2007

FIGURE 1-3



LEGEND



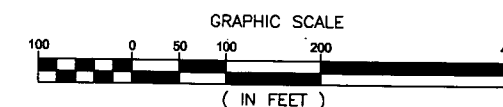
- MW-103 ● SHALLOW GROUNDWATER MONITORING WELL LOCATION
- MW-103DS ■ DEEP SAND GROUNDWATER MONITORING WELL LOCATION
- MW-N-3 ⊙ BEDROCK MONITORING WELL LOCATION
- TWP-SB-30 △ GROUNDWATER GRAB LOCATION
- ⊠ SEASONAL STANDING WATER SAMPLE LOCATION
- QUANTA PROPERTY BOUNDARY
- HUDSON RIVER SHORELINE

NOTES:

1. Depiction of other properties on this figure is for comparative purposes and does not necessarily suggest that Site-related constituents have migrated there.
2. Groundwater monitoring locations well to the north and south of the Site were evaluated in order to confirm the lateral extents of Site-related constituents. The use of these data in evaluations performed at the Quanta Resources Superfund Site does not necessarily indicate that impacts are related to the Quanta Resources Superfund Site.

Basemap Sources:

- a.) Boundary and topographic survey of Block 95, Lot 1 and Block 93, Lots 1,2, and 3 performed by Vargo Associates in September 2005 and updated as recently as June 2007.
- b.) Borough of Edgewater Tax Map - November, 1959.
- c.) Coal Tar Engineering Design Report (Environ, July 2005).
- d.) Site Investigation Report, Part 4 (Langan, May 2004) for the former Lever Bros. Property.



CH2MHILL

REMEDIAL INVESTIGATION GROUNDWATER MONITORING LOCATIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

November 6, 2007

FIGURE 1-4

extends beyond the lateral extent of NAPL in the form of staining or odors, as depicted in Figure 1-5 and described in detail in the final RI report (CH2M HILL, 2008a).

NAPL is present primarily in the form of residual and free-phase DNAPL, which is denser than water. DNAPL is present in shallow soils in discrete areas above and on top of the silty-clay confining layer. In addition, LNAPL, which is less dense than water, has been observed at MW-7, which is on the former Lever Brothers property. Detailed information regarding the nature and extent of NAPL is provided in the final RI report (CH2M HILL, 2008a).

Physical Properties of NAPL. With the exception of LNAPL at MW-7, NAPL samples collected were identified through chemical analysis as consisting of coal tar. Variances in the physical properties of the NAPL samples suggest that the properties have varying degrees of mobility in the subsurface under current conditions.

The specific gravity of the NAPL sampled from monitoring wells MW-102A, MW-105, MW-112B, MW-107, and MW-116B ranged from 1.0505 to 1.1293. The LNAPL collected at MW-7 was determined to have a specific gravity of 0.8772.

The kinematic viscosity of the LNAPL and NAPL that were sampled ranged from 3.49 to 181.6 centistokes (cSt) at 122°F. Samples collected from monitoring wells MW-107 (DNAPL) and MW-7 (LNAPL) exhibited the lowest viscosities, at 3.49 cSt and 4.93 cSt, respectively. Samples collected farther north were found to exhibit higher viscosity, such as those from MW-102A, at 14.31 cSt. NAPL with increasingly higher viscosities were observed still farther north, in monitoring well MW-112B, at 61.23 cSt, and along the Hudson River in MW-105, at 181.6 cSt. These data support field observations that NAPL observed at MW-112B and MW-105 was "thick" and difficult to penetrate with the sampling device. NAPL at MW-107 was the easiest to sample, and it flowed freely into the sample container.

Interfacial tension measured in the NAPL samples is consistent with values typical of NAPL at industrial sites, which usually ranges between 5 and 35 dynes/cm² (Advanced Applied Technology Development Facility, 1997; Cohen and Mercer, 1993). Interfacial tension values were lowest in the NAPL sample collected from monitoring well MW-107 (8.2 dynes/cm²) and highest in the NAPL sample collected from MW-105 (30.2 dynes/cm²).

With the exception of the NAPL detected to the south at monitoring well MW-107, the NAPL at OU1 has relatively elevated measured viscosity and interfacial tension, indicating a lower propensity for the NAPL to migrate. These data support field observations that indicated that NAPL at select monitoring wells was "thick" and difficult to penetrate with sampling and measurement devices.

Extent of NAPL. Extensive characterization has revealed that most NAPL at the site is present as part of one of four discrete NAPL zones (NZ-1, -2, -3, and -4). An additional zone (NZ-5) was identified on the basis of its proximity to the Hudson River and on the need to evaluate this material for the purposes of remedy selection. The NAPL zones are depicted in Figure 1-5. Although NAPL also exists outside these defined zones, the areas outside defined NAPL zones are generally characterized by the presence of residual NAPL only, or thin, discontinuous pockets of free-phase NAPL.

In NZ-1, high viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to a maximum depth of 11 feet bgs. At an isolated area (the vicinity of MW-102B and SB-9), NAPL has migrated to the depth of the silty-clay confining unit, approximately 25 feet bgs. In NZ-2, the high viscosity and interfacial tension have generally limited the migration of NAPL to approximately 14 feet bgs. NZ-3 consists of deeper NAPL in the central portion of the Quanta property and extending across the 115 River Road property onto the northern portion of the former Lever Brothers property. NAPL in NZ-3 is has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 feet bgs. NZ-4 consists of NAPL beneath Block 93 Central, Block 93 South, River Road, and the northwestern portion of the former Lever Brothers property. NAPL in NZ-4 is present in two separate layers: one between 10 and 15 feet bgs and one between approximately 20 and 30 feet bgs. The lateral and vertical extent of NZ-4 continues to be evaluated as part of the SRI. NAPL at NZ-5 adjacent to the Hudson River is present at depths of 18 to 25 feet bgs.

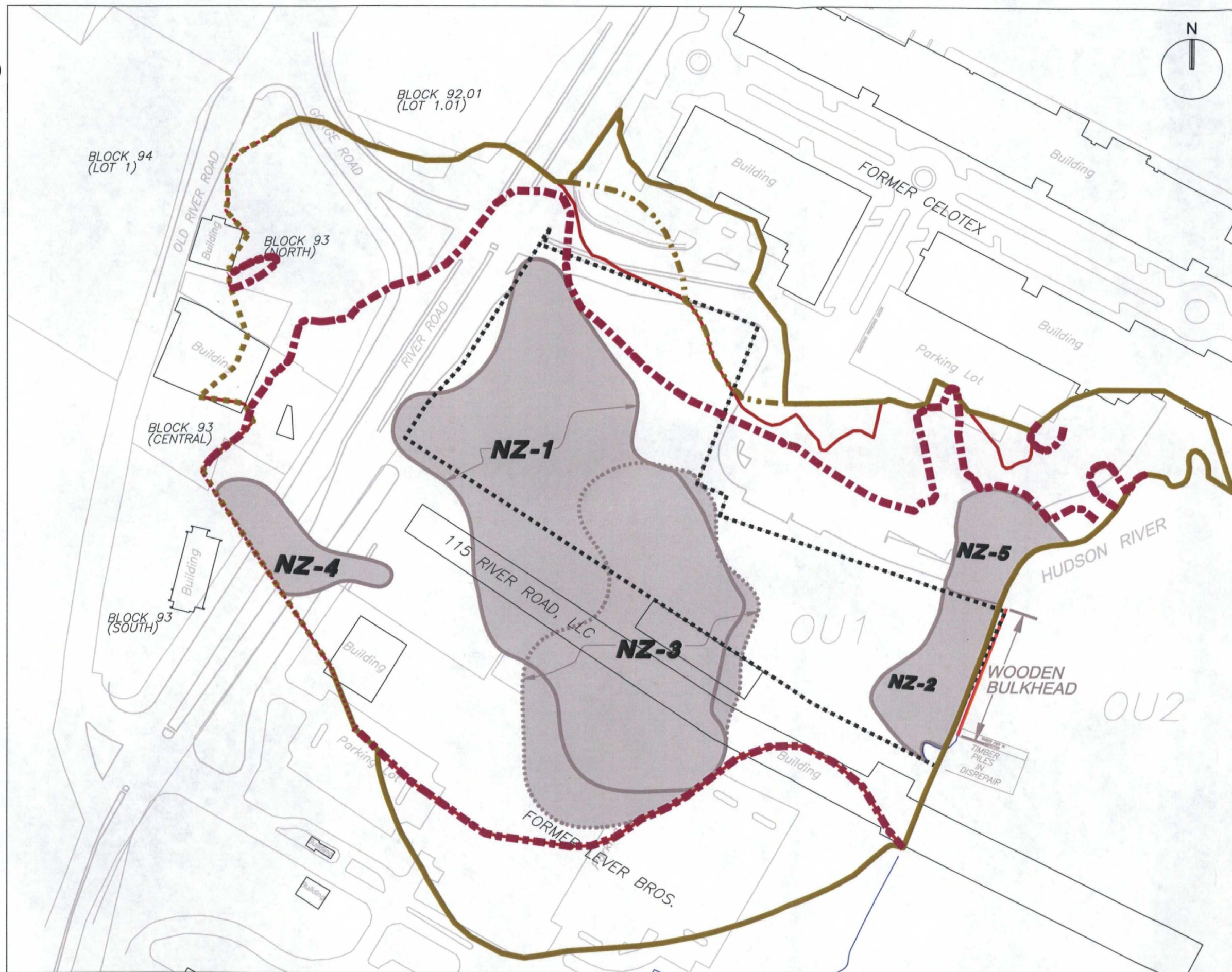
Solid tar has been observed in several soil borings at the site, most frequently in the form of a black, soft-to-stiff, semiplastic-to-plastic material at discrete depth intervals, with a thickness ranging from 0.3 foot to approximately 6 feet. Surficial tar boils, depicted on Figure 1-6, have been observed in areas similar to that of the solid tar.

The tar boils occur during the summer months when solid, semiplastic tar in the near subsurface vadose zone is heated by the sun and/or ambient air temperatures and seeps through surface cracks in soil or pavement. A visual "boil," or bubbling, of the material has been observed on very hot days (at or around 90°F) at the site. Once the tar reaches the surface, it either forms a bubble or spreads out laterally in thin layers within the preexisting, hardened tar (from past heating events). The lateral extent of a boil is generally less than 10 feet along its longest axis, and its thickness under 1 inch. The tar boils have been observed only as discontinuous entities at the Quanta property and have not been observed on the other properties included in the site. Tar boil materials and their constituents are generally defined as highly viscous liquid that are solid at room temperature and consist of a complex mixture of hydrocarbons and heterocyclic compounds. Coal tar is dominated by PAHs (typically around 85 percent PAHs) and has low aqueous solubility and high interfacial tension.

Nature and Extent of COIs in Soil

COIs detected in soil include SVOCs (predominantly PAHs), aromatic VOCs, and metals (principally arsenic and lead). COIs identified less frequently include chlorinated VOCs, pesticides, and PCBs.

VOCs and SVOCs. In general, the distribution of PAHs, aromatic VOCs, and other NAPL-related constituents (e.g., select non-PAH SVOCs) was observed to be coincident with the presence of NAPL or other sources. However, concentrations of PAHs and metals have also been observed consistently above screening criteria outside these areas. PAHs were not detected above the screening criteria in soil samples collected from the deep sand unit beneath the silty-clay aquitard. In areas where DNAPL is in close contact with the silty-clay, the presence of this material is anticipated to be limited to the upper several feet of this formation.



LEGEND

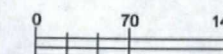
- QUANTA PROPERTY BOUNDARY
- HUDSON RIVER SHORELINE
- EXTENT OF QUANTA-RELATED SOIL & GROUNDWATER IMPACTS IN VICINITY OF THE HIGH ARSENIC AREA
- COMPOSITE EXTENT QUANTA RESOURCES SUPERFUND SITE (OU1) (INCLUDES THE HIGH ARSENIC AREA & QUANTA-RELATED CONSTITUENTS IN GROUNDWATER) - DASHED WHERE ADDITIONAL DELINEATION IS NEEDED
- LATERAL EXTENT OF NAPL BASED ON TarGOST®, SOIL BORING AND MONITORING WELL OBSERVATIONS (DOTTED WHERE ADDITIONAL DELINEATION NEEDED)
- LATERAL EXTENT OF COAL TAR BASED ON TarGOST®, SOIL BORING AND MONITORING WELL OBSERVATIONS. INCLUDES STAINED AND ODOROUS SOILS WHERE NAPL WAS NOT OBSERVED (DASHED WHERE ADDITIONAL DELINEATION NEEDED)
- NZ-2** NAPL ZONE

NOTES:

1. A discussion of the extents of the Quanta Resources Superfund Site, Operable Unit 1 (OU1) is provided in Section 4.0 of the RI Report.
2. Depiction of extents of constituents is based on the data presented in the RI report and is subject to change based on the results of the SRI.

Basemap Sources:

- a.) Boundary and topographic survey of Block 95, Lot 1 and Block 93, Lots 1,2, and 3 performed by Vargo Associates in September 2005 and updated as recently as June 2007.
- b.) Borough of Edgewater Tax Map - November, 1959.
- c.) Coal Tar Engineering Design Report (Environ, July 2005).
- d.) Site Investigation Report, Part 4 (Langan, May 2004) for the former Lever Bros. Property.



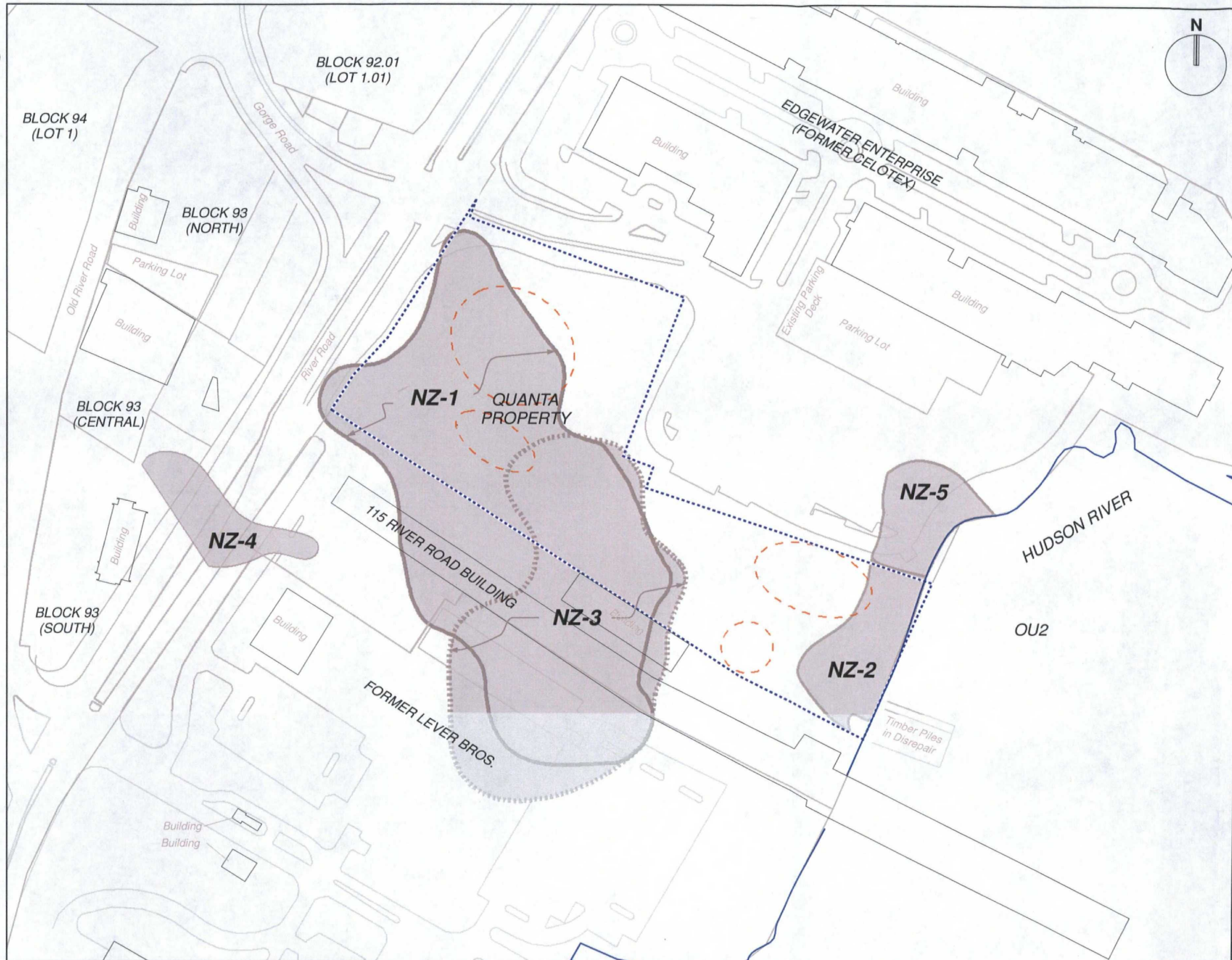
CH2MHILL

EXTENT OF QUANTA
RESOURCES SUPERFUND SITE
OPERABLE UNIT 1 (OU1)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

August 21, 2008

FIGURE 1-5

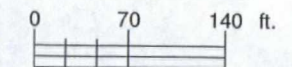


LEGEND

- Hudson River Shoreline
- Quanta Property Boundary
- - - Approximate area of tar "boils" (Not necessarily present throughout depicted area)
- NZ-2 NAPL Zone

Note:

1. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.



LATERAL EXTENT OF NAPL AND TAR BOILS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE 1-6

Chlorinated VOCs were detected in soil samples intermittently during RI investigation activities, predominantly in saturated soil samples. Chlorinated VOCs were detected less frequently in soil at the Quanta property compared to the adjacent properties, with the majority of the detections being in soils at the former Lever Brothers and former Celotex properties. The infrequent and low-level detections along with the irregular distribution of chlorinated solvents in soil suggest that no known, ongoing, site-related source of these constituents exists.

Inorganics. The two sources of elevated arsenic and lead identified within the extent of OU1 are (1) pyritic material associated with the former acid plant that once operated in the northwest portion of the Quanta property and at the former Celotex property and (2) ubiquitous heterogeneous fill containing coal, cinders, and slag. The extent of elevated arsenic concentrations in soil near the site of the former acid plant has been defined and does not extend beyond the southwestern portion of the former Celotex property and northwestern corner of the Quanta property. The extent and distribution of lead in soil has been defined and is different than that of arsenic (Figures 1-7 and 1-8).

Pesticides and PCBs. Pesticides in soil within OU1 represent isolated, noncontiguous release scenarios that are the likely result of the historical use of pesticides. Detected concentrations of PCBs in soil above the EPA Region 9 Residential PRG occur as discrete limited areas on each of the properties, primarily in the vadose zone. The detected PCB concentrations exceeding applicable screening criteria in the saturated zone are isolated to five sample locations in four isolated areas.

Nature and Extent of COIs in Groundwater

COIs identified in groundwater consist primarily of SVOCs (predominantly PAHs), aromatic VOCs, arsenic, lead, iron, ammonia, and, to a lesser extent, chlorinated VOCs, pesticides, and PCBs. The extent of site-related constituents in groundwater includes areas on the Quanta, 115 River Road, former Lever Brothers, former Celotex, and Block 93 North and Central properties (Figures 1-9 through 1-12).

VOCs and SVOCs. Naphthalene and benzo(a)pyrene were selected as representative PAHs at OU1 for the purposes of the RI. Naphthalene in groundwater extends farther downgradient from known areas of NAPL than does benzo(a)pyrene. In general, naphthalene in groundwater covers an area similar in shape and slightly greater than the portion of the OU1 in which evidence of NAPL has been identified. Similarly, the extent of dissolved-phase benzo(a)pyrene is limited to within the total lateral extent of NAPL, again, with the exception of areas where offsite sources are present.

The presence of most dissolved-phase PAHs is confined to the shallow fill and native sand deposits above the silty-clay aquitard. The extent of non-PAH SVOCs at OU1 are similar to the extent of PAHs and are located within the maximum detected lateral extent of naphthalene and benzo(a)pyrene.

Non-PAH SVOCs at OU1 consist primarily of phenolics (e.g., phenol and 2,4-dimethylphenol), dibenzofuran, and carbazole. Non-PAH SVOCs exceeded the applicable groundwater screening criteria in a lower percentage of RI groundwater samples than PAHs and are found primarily in the central portions of the site. Non-PAH SVOCs do not extend beyond the footprint of the naphthalene plume.

The distribution of benzene, a representative aromatic VOC, in groundwater is consistent with the known distribution of site-related NAPL. However, with a greater solubility in groundwater and a lower screening criterion, benzene exceedances in groundwater extend farther hydraulically downgradient of NAPL source material than naphthalene. The footprints of other site-related VOCs in groundwater at OU1 are located within the lateral extent of benzene.

Although chlorinated VOCs were detected in the deep sand groundwater, the lateral and vertical distribution of these compounds throughout the site, as well as the relationship of hydraulic heads between the shallow unconfined and deep sand units, indicates that the source of these chlorinated VOCs is not the result of a release or releases related to site-specific historical operations. Sporadic lower-level detections were observed in groundwater within the footprint of site-related constituents, as well as in offsite areas, as detailed in the final RI report (CH2M HILL, 2008a).

Inorganics. The presence of arsenic and iron in groundwater is a function of the relationship between redox potential (measured by oxidation reduction potential) and pH conditions in groundwater, which in turn are affected by the presence of organic material such as NAPL. Figure 1-13 depicts the location of reddish-purple soil, coal tar, and arsenic in groundwater. Because of source characteristics and the sensitivity to changes in groundwater geochemistry, the distribution of detected arsenic and iron at and adjacent to the site is reflected in the observation that concentrations of arsenic greater than 1,000 µg/L have been identified in groundwater at the following four distinct OU1 areas: (1) Block 93 near monitoring well MW-111, (2) near the former acid plant in the northwest portion of the Quanta property and the southwestern portion of the former Celotex property, (3) the northern portion of the former Lever Brothers property near monitoring well MW-107, and (4) the central portion of the former Lever Brothers property near the former pitch/asphaltic material area.

Due to differences in the nature and extent of the pyritic sources versus those of the regional fill material, and because lead, unlike arsenic, is not redox sensitive and is expected to be relatively immobile at the site, the distribution of lead in groundwater is distinctly different than that of arsenic and iron. Thus, the portions of the site where lead concentrations are greater than 50 µg/L are almost exclusively within the footprint the former acid plant (Figure 1-12).

Ammonia was stored at the site during historical coal-tar operations, but its distribution systems (i.e., piping systems) and potential use in manufacturing are not known. Ammonia concentrations above the lowest screening criterion (based on data collected in August and October 2006) covers the majority of the site, as described in the final RI report (CH2M HILL, 2008a).

Pesticides and PCBs. Groundwater-sampling results indicate that low concentrations of pesticides were detected within the interior portions of the Quanta property. These concentrations represent isolated, noncontiguous groundwater concentrations that are most likely the result of the historical use of pesticides. The PCB Aroclor-1260 was detected at one location in the central portion of the former Celotex property (monitoring well MW-J) during RI groundwater-sampling activities. Because PCBs adsorb strongly to soils and have

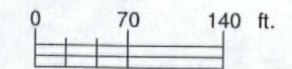


LEGEND

- Quanta Property Boundary
- 100— Lead (0 - 4 feet) Isoconcentration
- ||||| Lead (0 - 4 feet) Isoconcentration Area (> 1,000 mg/Kg)
- 100— Lead (> 4 feet) Isoconcentration
- ||||| Lead (> 4 feet) Isoconcentration Area (> 1,000 mg/Kg)

Note:

1. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.



**LEAD ISOCONCENTRATIONS IN SOIL
0 - 4 FEET AND > 4 FEET**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

February 19, 2009

FIGURE 1-7

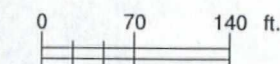


LEGEND

- Quanta Property Boundary
- 100— Arsenic (0 - 4 feet) Isoconcentration
- //// Arsenic (0 - 4 feet) Isoconcentration Area (> 100 mg/Kg)
- 100— Arsenic (> 4 feet) Isoconcentration
- //// Arsenic (> 4 feet) Isoconcentration Area (> 100 mg/Kg)

Note:

1. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.

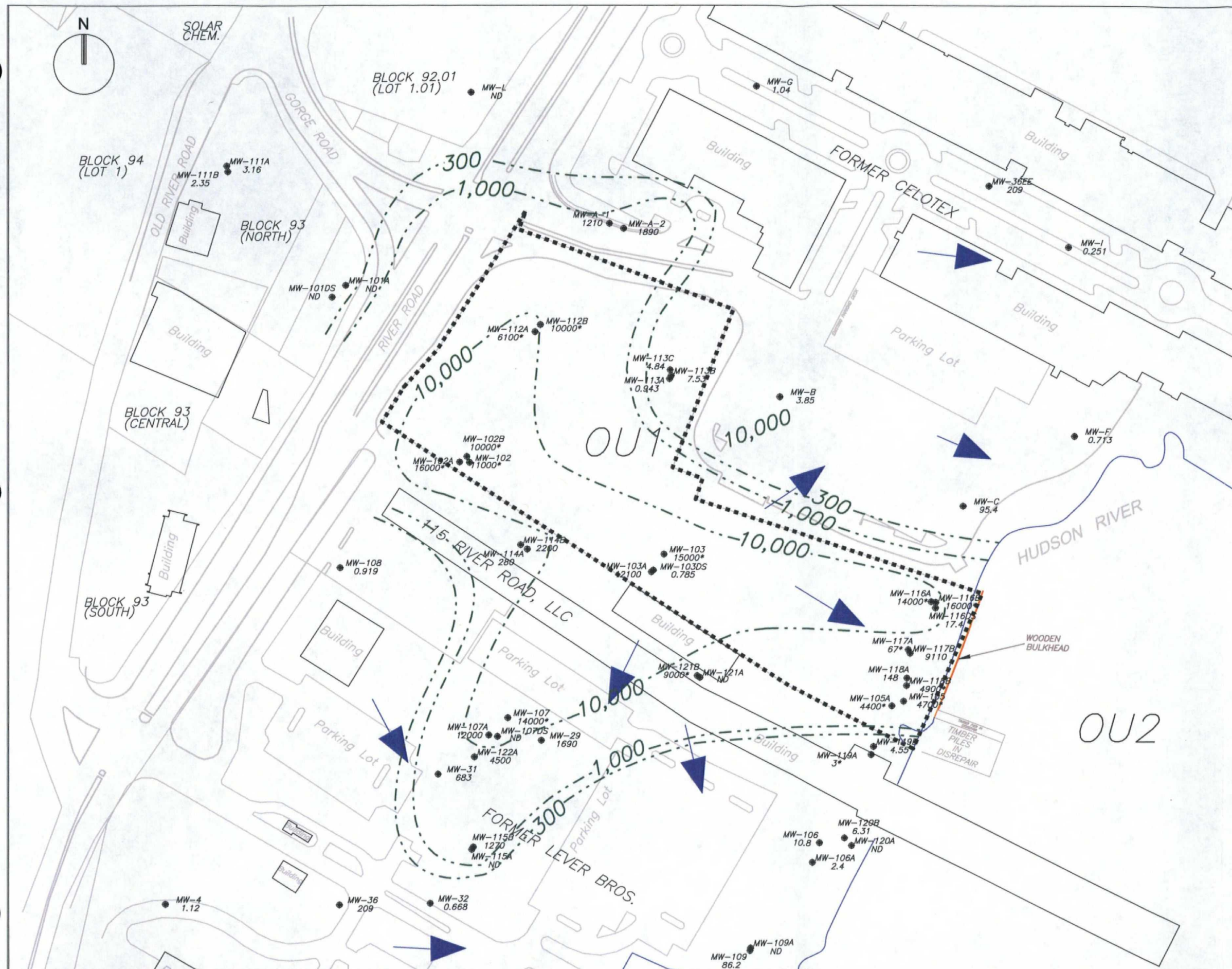


**ARSENIC ISOCONCENTRATIONS
IN SOIL, 0 - 4 FEET AND > 4 FEET**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

February 19, 2009

FIGURE 1-8



LEGEND

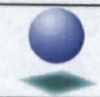
- MW-F 107
MONITORING WELL LOCATION WITH GROUNDWATER CONCENTRATION (ug/L)
- QUANTA PROPERTY BOUNDARY
- GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- HUDSON RIVER SHORELINE
- ➔ APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (OCT. 2006)

NOTES:

1. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.
2. Naphthalene Groundwater Screening Criteria:

NJ Class IIa Groundwater Quality Criteria	300 ug/L
USEPA Region 9 Tap Water PRG	6.2 ug/L
3. ND = not detected
4. Concentration contours were developed initially using kriging and the software Surfer 8.0. Computer generated contours were subsequently adjusted by hand. The highest concentration between colocated wells was used in contouring.
5. Block 93 North consists of Lot 1, Lot 2 (north portion), Lot 3, and Lot 3.04. Block 93 Central consists of Lot 2 (south portion) and Lot 1.01. Block 93 South consists of Lot 4 and 1.02.
6. Depiction of properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there.
7. Isoconcentration contour lines were not adjusted relative to the August and October 2006 isoconcentration contour lines if wells within the extent of the contour lines were not sampled during the respective groundwater sampling event. Changes to the contour lines were made only if dictated by the analytical data results or by review of time versus concentration plots (if analytical data were not available).
8. Analytical results with asterisks denote that that monitoring well was not sampled during the August groundwater sampling event. Thus, the posted results are from the most recent groundwater sampling event prior to the August event.

0 70 ft. 140 ft.



CH2MHILL

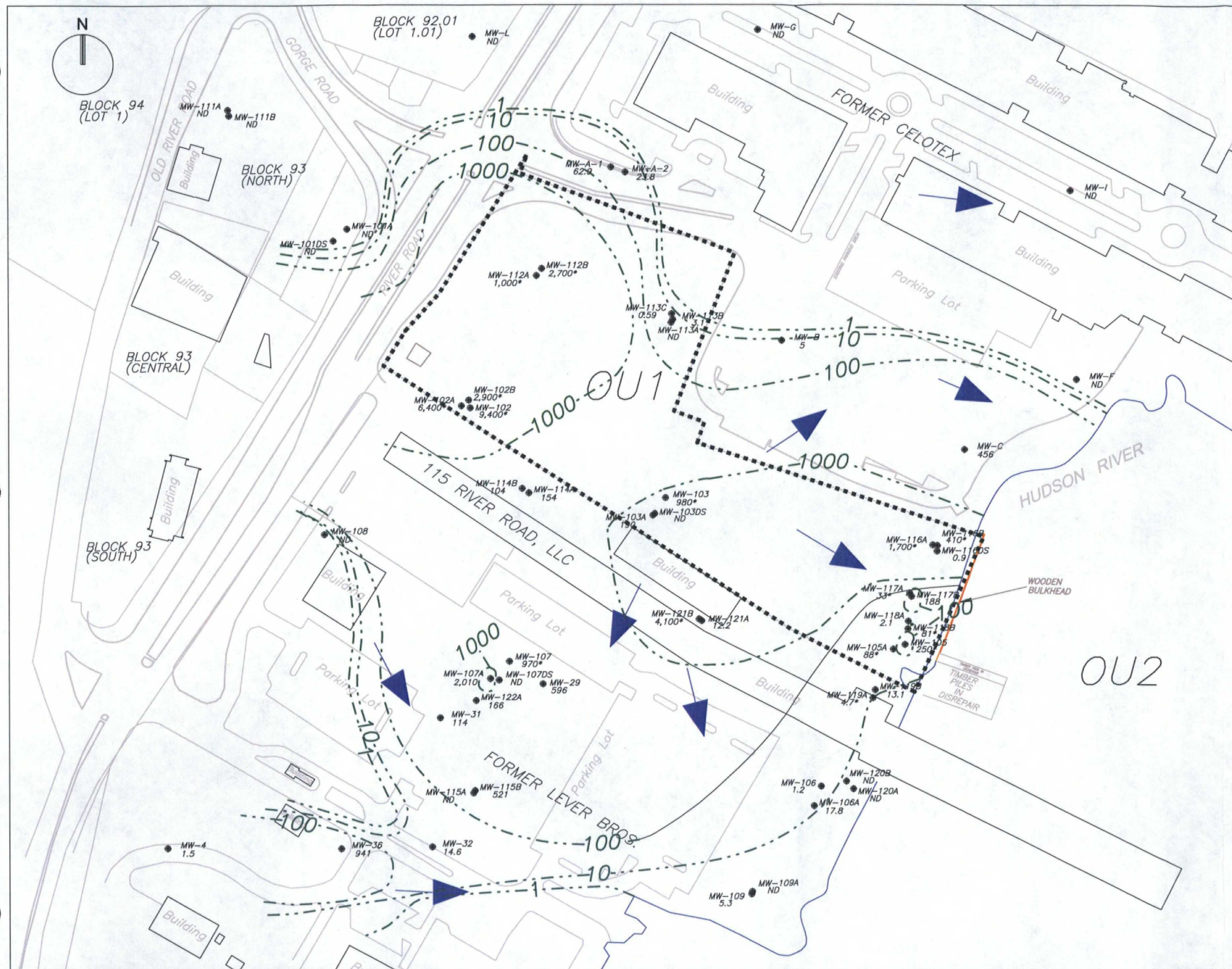
GROUNDWATER ISOCONCENTRATION CONTOURS

NAPHTHALENE (August 2006)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

June 9, 2008

FIGURE 1-9



LEGEND

- MW-F 107
MONITORING WELL LOCATION WITH GROUNDWATER CONCENTRATION (ug/L)
- QUANTA PROPERTY BOUNDARY
- - - - - GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- HUDSON RIVER SHORELINE
- ➔ APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (OCT. 2006)

NOTES:

1. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.
2. Benzene Groundwater Screening Criteria:

NJ Class IIA Groundwater Quality Criteria	1 ug/L
USEPA Region 9 Tap Water PRG	0.35 ug/L
3. ND = not detected
4. Concentration contours were developed initially using kriging and the software Surfer 8.0 @. Computer generated contours were subsequently adjusted by hand. The highest concentration between colocated wells was used in contouring.
5. Block 93 North consists of Lot 1, Lot 2 (north portion), Lot 3, and Lot 3.04. Block 93 Central consists of Lot 2 (south portion) and Lot 1.01. Block 93 South consists of Lot 4 and 1.02.
6. Depiction of properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there.
7. Isoconcentration contour lines were not adjusted relative to the August and October 2006 isoconcentration contour lines if wells within the extent of the contour lines were not sampled during the respective groundwater sampling event. Changes to the contour lines were made only if dictated by the analytical data results or by review of time versus concentration plots (if analytical data were not available).
8. Analytical results with asterisks denote that that monitoring well was not sampled during the August groundwater sampling event. Thus, the posted results are from the most recent groundwater sampling event prior to the August event.

0 70 ft. 140 ft.



CH2MHILL

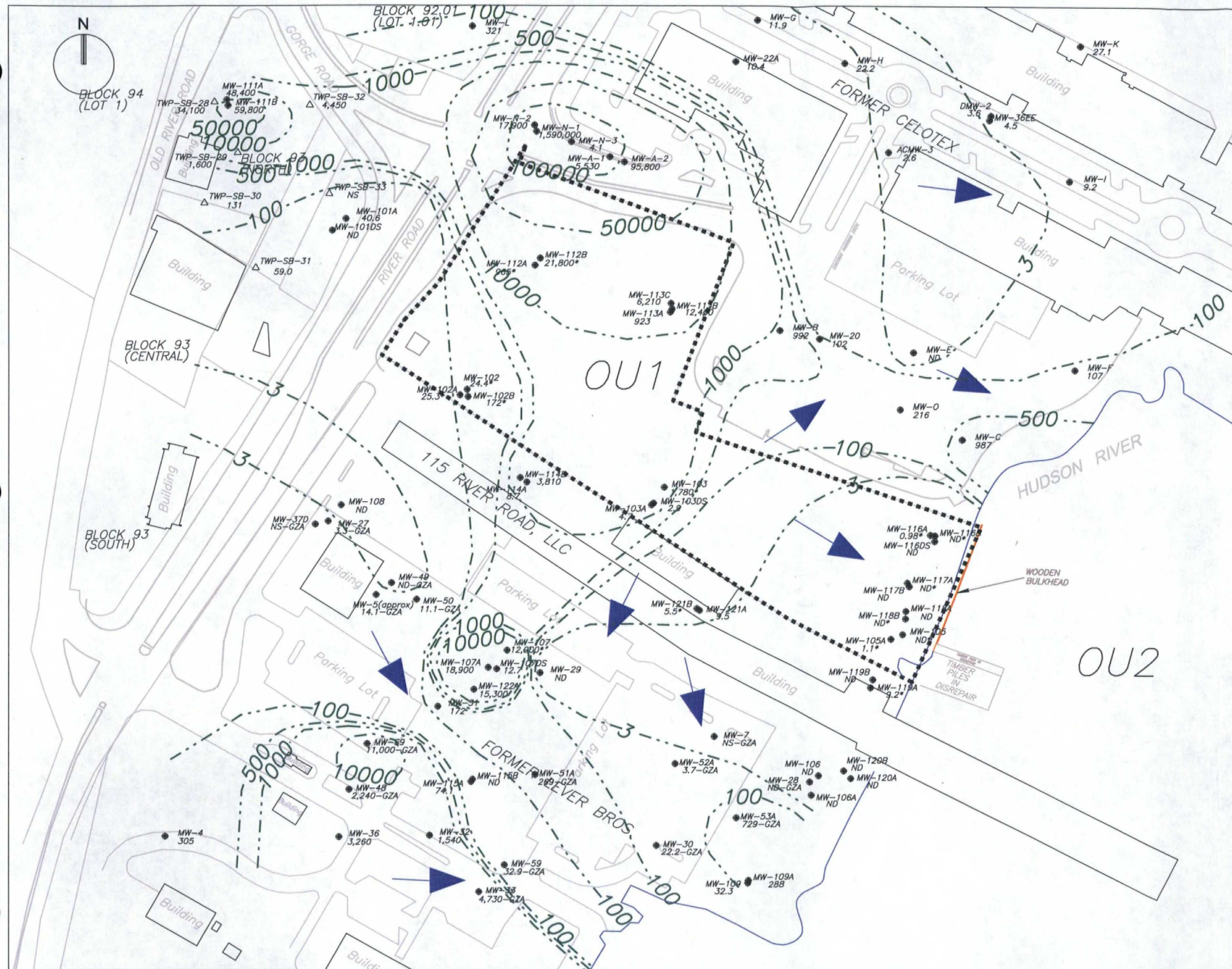
GROUNDWATER ISOCONCENTRATION CONTOURS

BENZENE (August 2006)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

June 9, 2008

FIGURE 1-10



LEGEND

- MW-F 107
MONITORING WELL LOCATION WITH GROUNDWATER CONCENTRATION (ug/L)
- QUANTA PROPERTY BOUNDARY
- - - - - GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- HUDSON RIVER SHORELINE
- APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (OCT. 2006)
- △ TWP-SB-31 59.0
GW GRAB LOCATION (JUNE 2007)

NOTES:

- Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.
- Arsenic Groundwater Screening Criteria:

NJ Class IIA Groundwater Quality Criteria	3 µg/L
USEPA Region 9 Tap Water PRG	0.045 µg/L
- ND = not detected
- Concentration contours were developed initially using kriging and the software Surfer 8.0. Computer generated contours were subsequently adjusted by hand. The highest concentration between collocated wells was used in contouring.
- Block 93 North consists of Lot 1, Lot 2 (north portion), Lot 3, and Lot 3.04. Block 93 Central consists of Lot 2 (south portion) and Lot 1.01. Block 93 South consists of Lot 4 and 1.02.
- Depiction of properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there.
- Isoconcentration contour lines were not adjusted relative to the August and October 2006 isoconcentration contour lines if wells within the extent of the contour lines were not sampled during the respective groundwater sampling event. Changes to the contour lines were made only if dictated by the analytical data results or by review of time versus concentration plots (if analytical data were not available).
- Analytical results with asterisks denote that that monitoring well was not sampled during the August groundwater sampling event. Thus, the posted results are from the most recent groundwater sampling event prior to the August event.

0 70 ft. 140 ft.

CH2MHILL

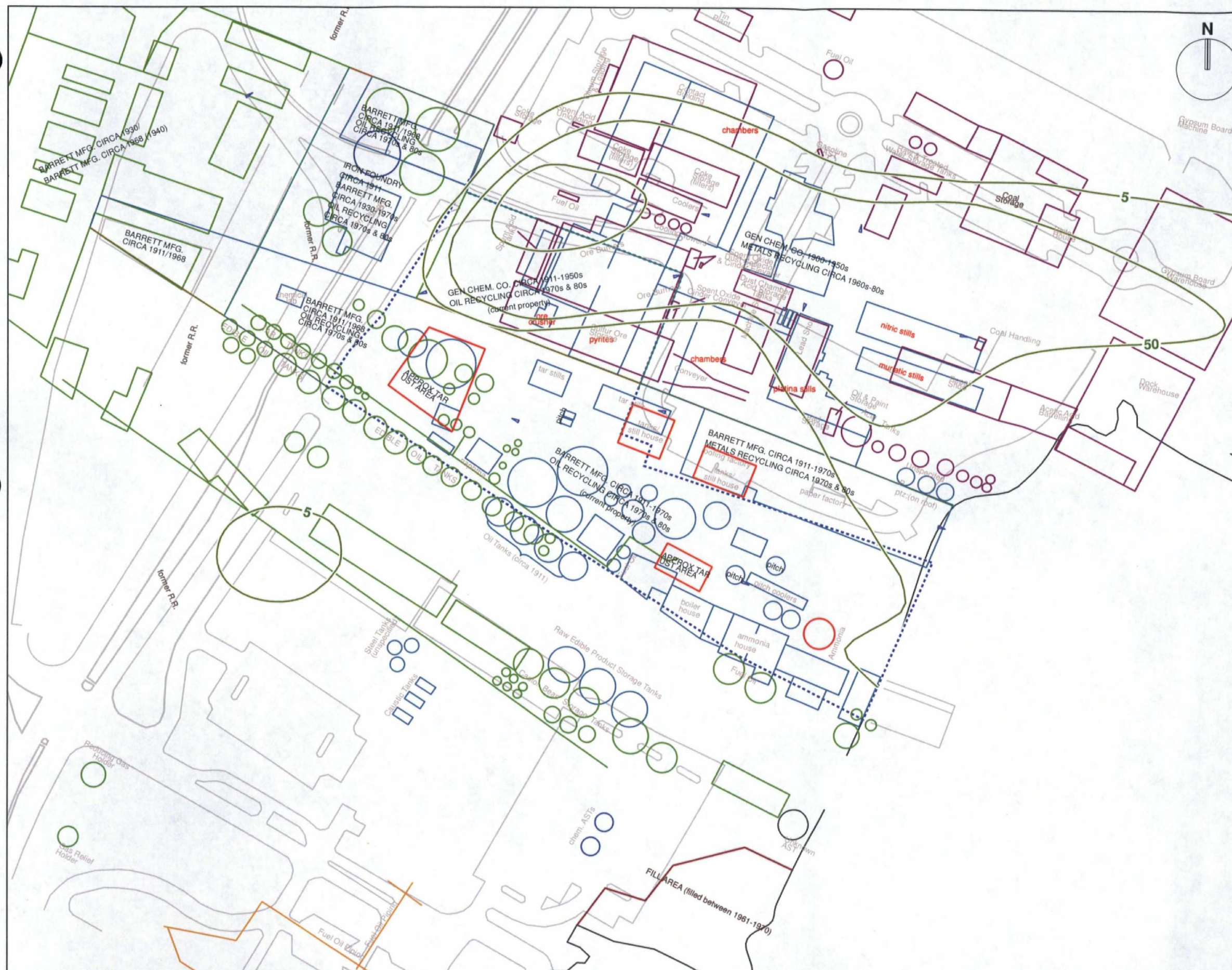
GROUNDWATER ISOCONCENTRATION CONTOURS

ARSENIC (2006-2007)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 31, 2008

FIGURE 1-11

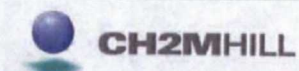
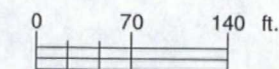


LEGEND

- Quanta Property Boundary
- 5 — Groundwater Lead Isoconcentration (ug/L)
- 1900 Former Buildings, ASTs, and USTs
- 1911 Former Buildings, ASTs, Property Boundaries (GENCHEM, Sanborn)
- 1911 - 1930 Property Boundaries (Sanborn)
- 1911 - 1970 Property Boundaries (Sanborn)
- 1930 Former Buildings, ASTs, Sub-surface Utilities, and Property Boundaries (Sanborn)
- 1930 - 1970 Property Boundaries (Sanborn)
- 1931 Former Oil Piping
- 1944 Former ASTs
- 1958 Former Buildings, and ASTs
- 1970 Former Fire Map Property Boundaries
- Fill Area
- Former USTs (GZA)

Note:

1. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.



EXTENT OF LEAD IN GROUNDWATER OVER HISTORIC SITE FEATURES

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE 1-12

not been detected in groundwater between the Quanta property and MW-J, this observed concentration is not considered related to site operations.

1.6.3 Fate and Transport

Relevant fate and transport processes controlling the migration of constituents at the site have been evaluated and are understood sufficiently to allow the development of remedial alternatives.

Fate and Transport of NAPL

The potential for NAPL migration varies among the defined discrete NAPL zones on the basis of the varying physical characteristics (e.g., viscosities, densities, and interfacial tensions) of NAPL samples collected across these areas (described in Section 1.5.3) as well as the physical characteristics of the subsurface. NAPL migration under current conditions has been evaluated for each of five NAPL zones (shown in Figure 1-5):

- In NZ-1, high viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to a maximum depth of 11 feet bgs. At an isolated area (the vicinity of MW-102B and SB-9), NAPL has migrated to the depth of the silty-clay confining unit, approximately 25 feet bgs. Further migration of NAPL in this zone is not predicted to occur, based on the physical characteristics of the NAPL. At MW-102B and SB-9, further migration is prevented by the presence of the silty-clay confining unit.
- In NZ-2, the high viscosity and interfacial tension have generally limited the migration of NAPL to approximately 14 feet bgs. The physical properties of the NAPL in this zone support the prediction that further migration under current conditions is unlikely (CH2M HILL, 2008a). A discrete interval of deeper NAPL below NZ-2 was also observed from 24 to 25 feet bgs at MW-116DS. Additional investigation in the vicinity of NZ-2 is being conducted as part of the SRI to better understand both the nature and extent of NAPL in this area, and the vertical extent of the wooden bulkhead. In light of the remaining uncertainty about this area and its close proximity to the Hudson River, the remedial alternative development, evaluation, and selection processes addresses potential migration at NZ-2.
- NZ-3 consists of deeper NAPL in the central portion of the Quanta property and extending across the 115 River Road property onto the northern portion of the former Lever Brothers property. The low-viscosity NAPL in NZ-3 has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 feet bgs. The upsloping surface of the silty-clay confining unit as well as the transition from native sands to low-permeability meadow mat and then to soft organic silts, both of which are physical barriers to NAPL movement in the direction of OU2, significantly limit lateral migration of NAPL in this zone.
- NZ-4 consists of NAPL beneath Block 93 Central, Block 93 South, River Road, and the northwestern portion of the former Lever Brothers property. NAPL in NZ-4 is present in two separate layers: one between 10 and 15 feet bgs and one between approximately 20 and 30 feet bgs. Potential migration of NAPL in NZ-4 is being determined through additional delineation work in this area (CH2M HILL, 2008b).

- NAPL at NZ-5 adjacent to the Hudson River is located between 18 and 25 feet bgs and further west on the former Celotex property was identified in borings and by TarGOST®. The available evidence supports the conclusion that most NAPL in this area is residual. However, due to the proximity of the NAPL to the Hudson River, this area has been included in the remedial alternative development, evaluation, and selection process to address potential migration at NZ-5.

The potential for altering subsurface conditions that play a role in NAPL mobility is an important consideration for the site. The effects of future development activities, such as excavating or placing fill material, placing subsurface structures, or pumping groundwater should be considered when specific development plans have been defined. Given the concern raised about the potential effect of additional fill on the NAPL at the site, a geotechnical evaluation is being performed as part of the SRI to evaluate potential future effects of redevelopment activities on NAPL mobility.

Fate and Transport of Constituents of Interest in Soil

Two major mechanisms exist for the transport of constituents in soil at the site: leaching and volatilization. Erosion, degradation, and bioaccumulation play less significant roles in the transport of COIs in soil at the site.

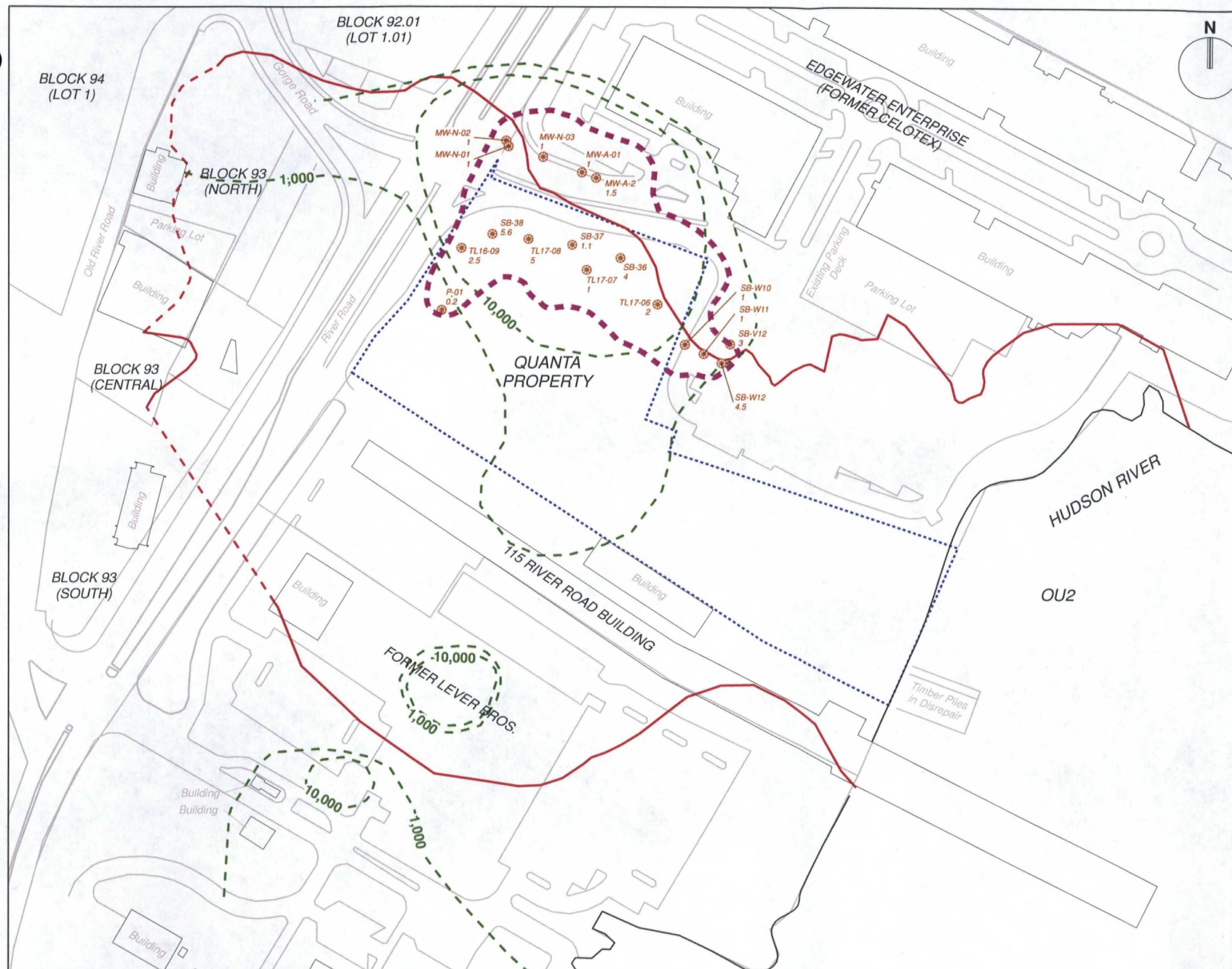
Although SVOCs (including PAHs) at OU1 generally adsorb strongly to soil particles and do not leach significantly, characteristics of the sources (i.e., NAPL) present in the subsurface and the length of time they have been present have resulted in the dissolution of SVOCs into groundwater at the site at levels exceeding applicable screening criteria. Since site-related constituents have been in place for approximately 25 to 130 years, it is assumed that potential volatilization of these constituents has already occurred and thus significant volatilization of SVOCs from surface soil is not expected to occur unless surface soil is disturbed.

Aromatic VOCs at the site, such as benzene, have leached from the soil to the groundwater. Benzene has a low affinity for adsorption; therefore, leaching has resulted in the presence of a large area of benzene in the saturated zone, compared to a relatively small area of benzene in the unsaturated zone (Figures 1-14a and 1-14b).

Two distinct sources of metals are at the site: the former acid plant and fill material. A distinct mineralogical difference exists between the brown-black fill and the reddish-purple soils within the footprint of the former acid plant. The reddish-purple soils include unburned or partially burned pyrite that is continuing to oxidize, ultimately producing reddish iron oxide minerals and elevated concentrations of iron along with metal impurities of the ore, such as arsenic, lead, copper, antimony, and thallium. In the slag-rich fill, the transport of metals in unsaturated soils is controlled by the adsorption and desorption of these metals to and from soil during the infiltration of rainwater. Fill samples were found to leach antimony, arsenic, copper, iron, and lead.

Pesticides and PCBs are present in limited areas of OU1 and adsorb strongly to soil particles, preventing their downward migration and transport in groundwater.

Significant additional migration of constituents in soil at OU1 is not expected to occur. Dissolved phase constituents are at equilibrium with all of the sources, including NAPL.



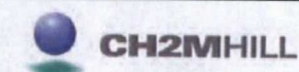
LEGEND

- Boring Location with Depth (FT BGS) at Which Reddish-Purple Soils Observed
- Quanta Property Boundary
- Groundwater Arsenic Isoconcentration - ug/L (2006)
- Lateral Extent of Coal Tar Based on TARGOST®, Soil Boring and Monitoring Well Observations, Includes Stained and Odorous Soils Where NAPL was not Observed (Dashed Where Additional Delineation Needed) (Coal Tar Engineering Report - Environ, July 2005)
- Approximate Area of Reddish-Purple Soil

Notes:

1. The extent of the reddish-purple soil is based on borings and soil sampling programs performed at the former Celotex property, the Quanta property, and to the west within River Road and beyond. Due to the large number of soil observations all locations could not be shown on this figure.
2. For detailed notes on the depiction of arsenic in groundwater please refer to Remedial Investigation Report.
3. Depiction of other properties on this figure is for comparative purposes and does not necessarily suggest that site-related constituents have migrated there.
4. Depiction of extent of constituents is based on the data presented in the RI Report and is subject to change based on the results of the SRI.

0 70 140 ft.



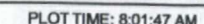
**EXTENT OF REDDISH-PURPLE SOILS,
ARSENIC IN GROUNDWATER,
AND COAL TAR**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

February 19, 2009

FIGURE 1-13





Limited infiltration and surface improvements prevent volatilization, erosion, leaching, or degradation from becoming significant transport mechanisms for constituents in unsaturated soil.

Fate and Transport of Constituents of Interest in Groundwater

Adsorption and degradation reactions are the most dominant attenuation factors for the fate of groundwater constituents at the site.

Concentrations of constituents in groundwater are generally constant over time. The footprint of the composite extent of site-related COIs in groundwater is not expanding under current conditions beyond its current boundary, as evidenced by concentration versus time plots and plots of groundwater plumes over time for key constituents. The more mobile dissolved-phase constituents in groundwater (benzene and naphthalene) have not migrated hydraulically downgradient beyond approximately 175 feet of the defined extents of site-related NAPL. As dissolved-phase constituents move from source areas at OU1 adjacent to the Hudson River upward through the sediments in OU2, they are subjected to further attenuation. The presence and nature of the groundwater connection between OU1 and OU2 will be refined on the basis of the SRI results.

In each of the distinct areas, arsenic in concentrations in groundwater greater than 1,000 µg/L is a function of the source of arsenic and groundwater geochemistry in the vicinity of localized sources. Likely sources of the arsenic include pockets of slag and cinders related to fill or the presence of pyritic material within the footprint of the former acid plant (the northwest portion of the Quanta property and the southern portion of the former Celotex property).

The most important attenuation mechanism for arsenic in groundwater is its adsorption to iron oxyhydroxides, which exhibit a strong affinity and high capacity for arsenic adsorption. Site-specific geochemical data within the elevated-arsenic areas indicate that arsenic has been reduced to the more mobile species arsenite (AsO_3^{3-}), and conditions are not suitable for the precipitation of key minerals (iron oxyhydroxides) that serve as the adsorption sites for the arsenic. In these geochemical areas where sources of arsenic, such as pyritic material and fill material, are present or just upgradient, concentrations of arsenic in groundwater are elevated. However, downgradient of source zones, geochemical conditions change so that the negatively charged forms of arsenate (AsO_4^{3-}) are the more dominant species, and iron oxyhydroxide precipitation is favored. At these geochemical transition zones, adsorption more readily occurs, resulting in the immobilization of arsenic and a subsequent reduction in the concentrations of dissolved arsenic in groundwater.

The presence of NAPL collocated with arsenic source material may be contributing to the dissolution of arsenic in groundwater by maintaining redox conditions that limit the formation of arsenic-adsorbing iron oxyhydroxides.

Concentrations of arsenic within and along the leading edge of the detected groundwater concentrations associated with each of the high-concentration arsenic areas (HCAAs) indicate that attenuation through adsorption and mineral precipitation is sufficient to stabilize and prevent further migration of arsenic beyond where it is observed. Arsenic near the former acid plant attenuates in groundwater through adsorption and does not migrate to the Hudson River. However, additional sources of arsenic related to fill have contributed

to the presence of dissolved-phase arsenic concentrations adjacent to the Hudson River. Arsenic that is not scavenged from groundwater prior to moving from these areas would be subject to additional attenuation in OU2. The presence and nature of the groundwater connection between OU1 and OU2 will be refined on the basis of results of the SRI.

In general, lead is strongly adsorbed under a wide range of pH and redox (Eh) conditions and is not transported readily in groundwater. Due to the relative immobility of lead, elevated concentrations of lead do not persist in groundwater downgradient to the south or east of the source because lead is adsorbed to organics or hydroxide minerals, or it is precipitated. Lead associated with the former acid plant attenuates in groundwater through adsorption and does not migrate to the Hudson River. Farther downgradient, concentrations increase slightly as a result of more modest sources in saturated soil that are separate from the pyritic material and could be a result of historical operations at the former Celotex property.

The random and isolated occurrences of pesticides in groundwater, as well as their chemical characteristics, indicate that pesticides are not mobile in groundwater at the site. PCBs were detected in groundwater in one location, the central portion of the former Celotex property, and are unrelated to former site operations. As with pesticides, the characteristics of PCBs and the isolated occurrence in groundwater indicate that PCBs are not transported in groundwater.

Ammonia in OU1 groundwater does not discharge to the Hudson River. Although concentrations of ammonia above screening levels are present, adsorption and microbial activity are attenuating factors, resulting in concentrations below screening criteria adjacent to the Hudson River.

1.6.4 Potential Pathways and Receptors

As a result of the sources and transport mechanisms described, site-related constituents at OU1 are contained in various media, including surface and subsurface soil, groundwater, and soil vapor. Sediment and surface water in the Hudson River are being evaluated as part of the RI for OU2. When exposed to these media, the constituents present can potentially pose a risk to certain human and/or ecological receptor populations. However, if no receptors are present the exposure pathway is incomplete and therefore no potential risk is posed by the constituents. The following subsections summarize the potential pathways and receptors present at the site and evaluated as part of the RI and draft baseline human health risk assessment (BHHRA) (CH2M HILL, 2007).

Human Health Risk Pathways and Receptors

Five human receptor types were identified with the potential for exposure to one or more media at OU1 that may contain site-related constituents under current and future site use scenarios. Trespassers/visitors, commercial workers and day care children could be exposed to constituents in surface soil under current use conditions through dermal absorption or ingestion, or to constituents in ambient air through inhalation. For potential future land use, potential receptors considered include construction/utility workers, commercial workers, daycare children, trespassers, and residents. These receptors have the potential to be exposed to constituents in groundwater or surface soil through either ingestion or dermal absorption, and to constituents in ambient and indoor air through

inhalation. Construction and utility workers could be exposed to constituents in groundwater through dermal absorption, to constituents in ambient air via inhalation, or to constituents in subsurface soil through ingestion or dermal absorption, under both current and future use scenarios.

Ecological Risk Pathways and Receptors

A screening-level ecological risk assessment (SLERA) has been completed for OU1. This SLERA evaluated potential risk to terrestrial receptors from exposure to compounds detected in surface soil on the 5.5-acre Quanta property. This SLERA evaluated potential ecological risk from direct exposure to soil and via the food-chain exposure pathway. Using conservative exposure scenarios and assumptions, this SLERA indicated potential risk to plant and invertebrate receptors via direct exposure and to higher-order receptors exposed to contamination through the food chain. The SLERA was refined using site-specific input parameters, which reduced the number of compounds indicating potential risk from direct exposure and limited the higher-order receptors at potential risk to small-mammal species. Based on the location of the site—in an urban area with limited and poor quality habitat available for receptor populations—future inhabitation of OU1 by these receptors is unlikely (CH2M HILL, 2006). In its July 7, 2006, comments on the SLERA, EPA concurred with the overall conclusion that additional characterization of ecological risk at OU1 was not necessary. However, receptors are present in the adjacent Hudson River, OU2, and site groundwater discharges to the river.

1.6.5 Human Health Risk Assessment

An HHRA was conducted for most of OU1 (with the exception of River and Gorge roads, Block 93 Central, and Block 93 South) and has identified COCs for three media:

- Surface soil (0 to 2 feet bgs)
- Subsurface soil (0 to 10 feet bgs)
- Groundwater (above and below the silty-clay confining layer)

Risks above acceptable levels for one or more existing or future receptors as a result of exposure to soil or groundwater were calculated on all properties evaluated. COCs that are the primary risk drivers at the site are naphthalene, arsenic, and carcinogenic PAHs. Along with these primary risk drivers, tar boils identified during the RI will be addressed during future remedial actions, because direct contact with this material is expected to exceed acceptable risk levels (CH2M HILL, 2007).

Studies of potential vapor intrusion pathways have been conducted at buildings at 115 River Road, Block 93 North (former Jono's Restaurant), and the former Lever Brothers property (Building 9). These studies have included groundwater, subslab and indoor air sampling, physical observations of the buildings, and air pressure measurements within buildings. The results from these studies indicate that the vapor intrusion pathways are unlikely to be present or are of a sufficiently small magnitude that they do not pose an unacceptable risk to the health of occupants of these buildings under current conditions.

Data obtained as part of the ongoing SRI will supplement existing data and allow sufficient characterization of human health risk at Block 93 Central and South and for groundwater at the site as a whole.

If a cumulative ELCR of 1×10^{-4} is exceeded for a given medium, the constituents that pose an individual ELCR greater than 1×10^{-6} for a potential receptor-property combination were identified as COCs. If a target organ-specific hazard index (HI) exceeds 1.0, the constituents that pose an individual hazard quotient (HQ) greater than 0.10 were identified as COCs. Table 1-1 presents the COCs identified for surface soil, subsurface soil, and shallow groundwater.

TABLE 1-1

Summary of Constituents of Concern

Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

COC	Surface Soil (0–2 ft bgs)	Subsurface Soil (0–10 ft bgs)	Shallow Groundwater
2-Methylnaphthalene	X	X	X
4-Methylphenol	X	—	—
Antimony	X	X	—
Aroclor-1242	X	—	—
Aroclor-1254	X	—	—
Aroclor-1260	X	—	—
Arsenic	X	X	X
Benzene	X	X	X
Benzo(a)anthracene	X	X	X
Benzo(a)pyrene	X	X	X
Benzo(b)fluoranthene	X	X	X
Benzo(k)fluoranthene	X	—	X
Carbazole	X	—	—
Chromium	X	—	—
Chrysene	X	—	—
Copper	X	—	—
Dibenzo(a,h)anthracene	X	X	X
Fluorene	X	—	—
Heptachlor	X	—	—
Indeno(1,2,3-cd)pyrene	X	X	X
Iron	X	X	—
Lead	X	X	—
Mercury	X	—	—
Naphthalene	X	X	X
Thallium	X	X	—
Xylenes, Total	X	—	—
Vanadium	X	—	—
Zinc	X	—	—

As presented in the Remedial Investigation Report (CH2M HILL, 2008). COCs are defined as contributing a chemical-specific Excess Lifetime Cancer Risk (ELCR) $> 1\text{E-}6$ or Hazard Index > 0.1 when receptor total ELCR (all soil pathways) $> 1\text{E-}6$ or Hazard Index > 1.0 . Surface soil is defined as 0 to 2 feet below ground surface. Subsurface soil is defined as 0 to 10 feet below ground surface.

The draft BHHRA identified arsenic, PAHs (primarily benzo(a)pyrene, dibenz(a,h)anthracene, benzo(b)fluoranthene, and benzo(a)anthracene) and naphthalene as the primary risk drivers for most media and receptors evaluated. Table 1-2 presents the relative risk contributions for each of these constituents. On the basis of the BHHRA conclusions, the remedial alternatives will target these primary risk drivers, as well as NAPL (a source of PAHs and naphthalene). Although the complete list of COCs will be considered, it is believed that if the primary risk drivers and NAPL are adequately addressed, RAOs will be achieved.

1.6.6 Summary of Conceptual Site Model

Coal tar processing and subsequent oil-recycling operations contributed to existing secondary sources of contamination at the site, including NAPL, pitch, soil impacted with PAHs, and other constituents. A former acid plant on the northern portion of the Quanta property and southern portion of the former Celotex property contributed to the presence of oxidizing pyrite ore remnants in soil. Primary sources are no longer present, with the possible exception of buried piping on the Quanta property. Additional secondary sources contributing to soil and groundwater contamination unrelated to former operations (such as regional fill material and former operations on adjacent properties) are present within the extent of OU1.

The location, nature, and extent of most of the NAPL at OU1 have been defined. The current understanding of NAPL location is being refined as part of the SRI. Most free-phase NAPL is present in discrete areas (or zones) above and within the top few feet of the silty clay confining layer. To some extent, free-phase NAPL is recoverable but does not appear to be migrating under current conditions, with the possible exception of NAPL within zones adjacent to the Hudson River. Additional evaluation of this potential migration is being performed as part of the SRI (CH2M HILL, 2008a). The results of the RI indicate that NAPL at OU1 is generally stable under current conditions. Migration is constrained by either the physical properties of the NAPL (e.g., high viscosity and interfacial tension), the soil pore size, or physical barriers such as the silty clay confining unit and shallower organic silt deposits. Solid tar has been observed in the form of a black, soft-to-stiff, semiplastic-to-plastic material up to 6 feet bgs. Tar boils have also been observed at the ground surface within or near the solid-tar areas.

An HHRA was conducted for most of OU1 (with the exception of River and Gorge Roads, Block 93 Central, and Block 93 South), and has identified COCs for surface soil, subsurface soil, and groundwater. The primary risk drivers at the site are carcinogenic PAHs, naphthalene, and arsenic. Along with these primary risk drivers, surficial tar boils are presumed to pose an unacceptable risk.

Concentrations of COCs in groundwater have remained similar over time and concentrations decline with distance from sources. At the site, the footprint of the composite extent of COCs in groundwater is not expanding; concentrations of constituents in groundwater are generally in equilibrium as a result of adsorption and degradation processes.

TABLE 1-2

Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹
 Reasonable Maximum Exposure Scenario
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil		Groundwater (Above Confining Unit)	
Site: Quanta Resources						
Adult Trespasser			Construction Worker		Construction Worker	
Arsenic	33.8%		Antimony	1.2%	2-Methylnaphthalene	3.6%
Benzo(a)anthracene	4.9%		Arsenic	55.55% 49.1%	Benzo(a)anthracene	5.7%
Benzo(a)pyrene	44.2%		Iron	0.7%	Benzo(a)pyrene	70.7%
Benzo(b)fluoranthene	5.2%		Thallium	0.5%	Benzo(b)fluoranthene	8.2%
Dibenz(a,h)anthracene	8.9%		2-Methylnaphthalene	0.8%	Benzo(k)fluoranthene	0.4%
Indeno(1,2,3-c,d)pyrene	2.5%		Benzo(a)anthracene	3.2%	Dibenz(a,h)anthracene	11.1%
			Benzo(a)pyrene	30.6%	Indeno(1,2,3-c,d)pyrene	3.7%
			Benzo(b)fluoranthene	3.5%	Naphthalene	93.1%
			Dibenz(a,h)anthracene	5.0%	Benzene	1.7%
			Indeno(1,2,3-c,d)pyrene	1.6%		
			Naphthalene	46.0%		
			Benzene	0.1% 0.2%		
Adolescent Trespasser						
Arsenic	11.1%					
Benzo(a)anthracene	6.5%					
Benzo(a)pyrene	59.5%					
Benzo(b)fluoranthene	7.0%					
Dibenz(a,h)anthracene	11.9%					
Indeno(1,2,3-c,d)pyrene	3.3%					
Commercial Worker						
Arsenic	26.0%	30.7%				
Aroclor-1242	0.1%					
Aroclor-1260	0.1%					

TABLE 1-2Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹

Reasonable Maximum Exposure Scenario

Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil	Groundwater (Above Confining Unit)
Benzo(a)anthracene	5.3%		
Benzo(a)pyrene	48.7%		
Benzo(b)fluoranthene	5.7%		
Benzo(k)fluoranthene	0.3%		
Dibenz(a,h)anthracene	9.8%		
Indeno(1,2,3-c,d)pyrene	2.7%		
Naphthalene		53.3%	
Benzene	0.8%		
Trichloroethene	0.3%		
Adult Resident			
Antimony		3.1%	
Arsenic		38.8%	
Iron		5.9%	
Thallium		0.9%	
2-Methylnaphthalene		0.5%	
Naphthalene		41.9%	
Benzene		1.4%	
Child Resident			
Antimony		4.7%	
Arsenic		57.5%	

TABLE 1-2Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹

Reasonable Maximum Exposure Scenario

Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil	Groundwater (Above Confining Unit)
Copper	1.6%		
Iron	9.1%		
Thallium	1.3%		
Vanadium	1.0%		
Zinc	0.1%		
Mercury	1.1%		
Aroclor-1242	2.4%		
Aroclor-1260	1.2%		
2-Methylnaphthalene	0.8%		
4-Methylphenol	0.3%		
Fluorene	0.1%		
Naphthalene	16.7%		
Benzene	0.6%		
Adult/Child Aggregate Resident			
Arsenic	8.6%		
Heptachlor	0.01%		
Aroclor-1242	0.03%		
Aroclor-1260	0.02%		
Benzo(a)anthracene	6.7%		
Benzo(a)pyrene	61.2%		

TABLE 1-2Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹

Reasonable Maximum Exposure Scenario

Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil		Groundwater (Above Confining Unit)	
Benzo(b)fluoranthene	7.2%				
Benzo(k)fluoranthene	0.3%				
Carbazole	0.01%				
Chrysene	0.1%				
Dibenz(a,h)anthracene	12.3%				
Indeno(1,2,3-c,d)pyrene	3.4%				
Benzene	0.1%				
Trichloroethene	0.03%				
Site: Edgewater					
Adult/Child Aggregate Resident		Construction Worker		Construction Worker	
Arsenic	10.4%	Arsenic	47.6%	Arsenic	79.45%
Benzo(a)anthracene	6.4%	2-Methylnaphthalene	1.6%	Naphthalene	19.81%
Benzo(a)pyrene	60.1%	Naphthalene	30.9%		
Benzo(b)fluoranthene	5.8%				
Dibenz(a,h)anthracene	13.9%				
Indeno(1,2,3-c,d)pyrene	3.4%				
Site: 115 River Road					
Daycare Child		Construction Worker		Construction Worker	
Arsenic	0.7%	Arsenic	2.0%	Naphthalene	96.4%
Benzo(a)anthracene	7.5%	2-Methylnaphthalene	8.8%		

TABLE 1-2

Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹
 Reasonable Maximum Exposure Scenario
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil		Groundwater (Above Confining Unit)	
Benzo(a)pyrene	66.7%	Benzo(a)anthracene	10.1%		
Benzo(b)fluoranthene	8.3%	Benzo(a)pyrene	65.1%		
Benzo(k)fluoranthene	0.4%	Benzo(b)fluoranthene	6.9%		
Dibenz(a,h)anthracene	12.3%	Dibenz(a,h)anthracene	11.0%		
Indeno(1,2,3-c,d)pyrene	4.0%	Indeno(1,2,3-c,d)pyrene	2.9%		
Chromium	0.2%	Naphthalene		81.5%	
Naphthalene	83.2%				

Site: Former Lever Brothers

Adolescent Trespasser		Construction Worker		Construction Worker	
Arsenic	5.4%	Arsenic	55.9%	Arsenic	7.7%
Benzo(a)anthracene	6.5%	Naphthalene	12.1%	2-Methylnaphthalene	6.4%
Benzo(a)pyrene	64.7%			Naphthalene	80.9%
Benzo(b)fluoranthene	8.4%				
Dibenz(a,h)anthracene	10.7%				
Indeno(1,2,3-c,d)pyrene	3.9%				

Site: Block 93 North

Adult Trespasser		Construction Worker		Construction Worker	
Arsenic	15.9%	Arsenic	3.3%	Arsenic	91.7%
Benzo(a)anthracene	8.9%	2-Methylnaphthalene	2.6%	Naphthalene	0.5%
Benzo(a)pyrene	55.2%	Naphthalene	86.6%		

TABLE 1-2Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹

Reasonable Maximum Exposure Scenario

Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil	Groundwater (Above Confining Unit)
Benzo(b)fluoranthene	5.8%		
Benzo(k)fluoranthene	0.5%		
Dibenz(a,h)anthracene	10.2%		
Indeno(1,2,3-c,d)pyrene	3.0%		
Adolescent Trespasser			
Arsenic	4.5%		
Benzo(a)anthracene	10.1%		
Benzo(a)pyrene	63.0%		
Benzo(b)fluoranthene	6.6%		
Benzo(k)fluoranthene	0.5%		
Dibenz(a,h)anthracene	11.6%		
Indeno(1,2,3-c,d)pyrene	3.5%		
Commercial Worker			
Arsenic	11.6%		
Aroclor-1260	0.2%		
Benzo(a)anthracene	9.2%		
Benzo(a)pyrene	57.4%		
Benzo(b)fluoranthene	6.0%		
Benzo(k)fluoranthene	0.5%		
Dibenz(a,h)anthracene	10.6%		

TABLE 1-2

Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹
 Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil		Groundwater (Above Confining Unit)	
Indeno(1,2,3-c,d)pyrene	3.2%				
Naphthalene		84.2%			
Benzene	1.1%				
Site-Wide Groundwater (Above the Confining Unit)					
Adult Resident		Child Resident		Adult/Child Aggregate Resident	
Arsenic	94.0%	Arsenic	99.3%	Arsenic	50.8%
Iron	0.2%	Iron	0.2%	alpha-BHC	0.0002%
Benzene	0.2%	Benzene	0.1%	delta-BHC	0.0002%
Ethylbenzene	0.003%	Ethylbenzene	0.002%	Heptachlor	0.0001%
Toluene	0.005%	Toluene	0.004%	Benzene	0.2%
Trichloroethene	0.004%	Trichloroethene	0.004%	Trichloroethene	0.004%
m,p-Xylene	0.01%	m,p-Xylene	0.001%	Benzo(a)anthracene	2.0%
o-Xylene	0.01%	o-Xylene	0.001%	Benzo(a)pyrene	42.7%
Xylene (Total)	0.02%	Xylene (Total)	0.002%	Benzo(b)fluoranthene	2.8%
2,4-Dimethylphenol	0.02%	2,4-Dimethylphenol	0.02%	Benzo(k)fluoranthene	0.1%
2-Methylnaphthalene	0.1%	2-Methylnaphthalene	0.1%	Carbazole	0.003%
2-Methylphenol	0.002%	2-Methylphenol	0.002%	Chrysene	0.02%
3&4-Methylphenol	0.002%	3&4-Methylphenol	0.002%	Indeno(1,2,3-c,d)pyrene	1.3%
4-Methylphenol	0.1%	4-Methylphenol	0.1%		
Acenaphthene	0.004%	Acenaphthene	0.004%		

TABLE 1-2Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern¹

Reasonable Maximum Exposure Scenario

Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil		Subsurface Soil		Groundwater (Above Confining Unit)	
Benzo(g,h,i)perylene	0.01%	Acenaphthylene	0.001%		
1,1'-Biphenyl	0.001%	Benzo(g,h,i)perylene	0.01%		
Fluoranthene	0.01%	1,1'-Biphenyl	0.001%		
Naphthalene	5.2%	Fluoranthene	0.01%		
Pyrene	0.01%	Fluorene	0.002%		
		Naphthalene	0.2%		
		Pyrene	0.01%		
Site-Wide Groundwater (Below the Confining Unit)					
Adult Resident		Child Resident		Adult/Child Aggregate Resident	
Trichloroethene	75.3%	Arsenic	1.2%	Arsenic	1.9%
2-Methylnaphthalene	0.2%	Trichloroethene	97.2%	Benzene	0.2%
Naphthalene	23.0%			Tetrachloroethene	2.0%
				Trichloroethene	93.7%
				Vinyl chloride	0.04%
				Benzo(a)anthracene	2.1%
				Carbazole	0.02%

Studies of potential vapor intrusion pathways conclude that they either are unlikely to be present or have been determined not to pose an unacceptable human health risk to current receptors. On the basis of the location of the site—in an urban area with limited and poor-quality habitat available for receptor populations—the conclusion of the SLERA (CH2M HILL, 2006) was that it is unlikely that ecological receptors inhabit OU1.

A complete conceptual site model and the detailed information on which the model is based can be found in the final RI report (CH2M HILL, 2008a). Further delineation of OU1 has been proposed in the final “Remedial Investigation/Feasibility Study Work Plan Addendum No. 4 for a Supplemental Remedial Investigation” (CH2M HILL, 2008b), the results of which will be evaluated prior to remedy implementation. The SRI is addressing remaining data gaps that will have specific bearing on remedial design and implementation and includes the following objectives:

- Determine the nature and extent of site-related constituents and arsenic in the vicinity of Block 93 and the northwest portion of the former Lever Brothers property and in the intersection of Gorge and River roads
- Determine the nature and extent of NAPL in the northeastern portion of the former Lever Brothers property (near MW-106A)
- Refine the nature and extent of NAPL behind and at the flanks of the wooden bulkhead
- Determine the dimensions of the wooden bulkhead and evaluate its role in limiting NAPL migration
- Supplement existing data to sufficiently characterize potential risk to human health at Block 93 Central and South and for groundwater at the site as a whole
- Begin collection of data to confirm stability of organic constituents and arsenic in groundwater at OU1
- Confirm distribution and mobility of arsenic in groundwater within and downgradient of suspected source zones at OU1
- Characterize groundwater flow paths and distribution and fate and transport of coal tar constituents (VOCs and PAHs) and arsenic across the groundwater–surface water transition zone(s) between OU1 and OU2

1.7 Principal Threat Evaluation

EPA guidance on principal threat and low-level threat waste has characterized source material on the basis of hazard and risk and to identify appropriate waste management options for this material (EPA, 1991). This guidance states that principal threat wastes are “those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur” (p. 2). Low-level threat wastes are those source materials that generally can be reliably contained and that would pose only a low risk in the event of exposure. EPA expects to use “treatment to address the principal threats posed by a

site, wherever practicable" and "engineering controls, such as containment, for waste that poses a relatively low long-term threat" (p. 1).

According to EPA (1991) guidance, principal threat wastes exist for OU1. Eight areas within OU1 were determined to contain source material, based on the various characteristics presented in Table 1-3:

- NAPL Zone 1
- NAPL Zone 2
- NAPL Zone 3
- NAPL Zone 4
- NAPL Zone 5
- Tar boils
- HCAA (former Celotex)
- HCAA (Quanta and Block 93 North)

TABLE 1-3

Source Material Determination
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Source Material Definition Criteria*	NAPL Zone					Tar Boils	HCAA	
	1	2	3	4	5		Celotex	Quanta
Contains hazardous material that migrates to groundwater?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contains hazardous material that migrates directly to surface water?	No	Yes	No	No	Yes	No	No	No
Contains hazardous material that migrates to air?	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Acts as a source for direct exposure (within 10 feet bgs)?	Yes	Yes	No	Yes	No	Yes	No	Yes
Source Material?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:

*Source definition criteria are based on A Guide to Principal Threat and Low Level Threat Wastes (EPA, 1991).

bgs - below ground surface

HCAA - High Concentration Arsenic Area

NAPL - Non-Aqueous Phase Liquid

Each of these source areas was evaluated as presented in Table 1-4 to determine on the basis of toxicity and mobility potential whether the material is a low-level threat waste or a principal threat waste. Determination was made whether each area's potential to exhibit toxicity and/or mobility was low, moderate, or high.

On the basis of the following evaluation, which is consistent with EPA guidance, five of these areas were positively identified as containing principal threat wastes. The remedial alternatives outlined in Section 4 include treatment options such as solidification/stabilization or in situ chemical oxidation (ISCO) to address principal threat

waste. Low-level threat waste is generally addressed by engineering and institutional controls, such as capping and a deed notice.

1.7.1 Mobility Potential

Highly mobile material refers to source material that is not reliably contained and has a significant potential to migrate to surface water, to sediments, or to air or act as a source for direct exposure (EPA, 1991).

The most important characteristic contributing to potential mobility is the ability of the source material itself to move through the subsurface (e.g., potential for NAPL to migrate). Highly mobile source material consists of unimpeded low-viscosity liquid, whereas low-mobility material could consist of either trapped low-viscosity liquid or high-viscosity liquid or solids.

NAPL Zone 1

The potential mobility of source material at NZ-1 was determined to be low. High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to 11 feet bgs or less. Further migration is not predicted to occur, given the physical characteristics of the NAPL that resulted in the presence of NAPL at NZ-1. At an isolated area within NZ-1, NAPL has migrated to the depth of the silty-clay confining unit (approximately 25 feet bgs). At this location, further migration is prevented by the configuration of the confining unit.

NAPL Zone 2

At NZ-2, medium to very high viscosity (up to 181.6 cSt at 122°F) and high interfacial tension (18.0 to 30.2 dynes/cm²) have generally limited the migration of NAPL to approximately 14 feet bgs, and further migration under current conditions is unlikely. In light of the remaining uncertainty in this area with regard to a discrete interval of deeper NAPL observed at MW-116DS and the unknown vertical extent of the wooden bulkhead, additional investigation is being conducted. The presence and nature of the connection between OU1 and OU2 will be refined based on the results of the SRI. However, due to the proximity of the NAPL to the Hudson River, the remedial alternative development, evaluation, and selection address potential migration at NZ-2. This material is considered a principal threat waste.

NAPL Zone 3

The potential mobility of source material at NZ-3 was determined to be low. Although NAPL in NZ-3 has lower viscosity and interfacial tension (viscosity of 3.49 cSt and interfacial tension of 8.2 dynes/cm² in a NAPL sample collected at monitoring well MW-107) and would therefore flow if unimpeded, it has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 feet bgs. Gravitational forces and the impermeability of the confining layer prevent further downward and lateral migration of the NAPL; therefore the mobility potential at NZ-3 is low.

TABLE 1-4
Source Material Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Source Area	Mobility Potential	Toxicity Potential		
		Accessibility/Proximity to Receptors	Vapor Intrusion	Principal Threat Waste?
NZ-1	LOW: High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to a maximum depth of 11 feet bgs. Further migration of NAPL in this zone is not predicted to occur, based on the physical characteristics of the NAPL and the likely age of release(s) that resulted in the presence of NAPL at this location. At an isolated area, NAPL has migrated to the depth of the silty-clay confining unit (approx. 25 feet bgs). At this location, further migration is prevented by the presence of the silty-clay confining unit.	HIGH: NAPL containing COCs is present at depths posing a risk of direct contact.	HIGH: NAPL containing COCs is present at depths posing a risk of vapor intrusion.	Yes - Toxicity Potential
NZ-2	CONSERVATIVELY ASSUMED HIGH: High viscosity and interfacial tension have generally limited the migration of NAPL to approximately 14 feet bgs, and further migration under current conditions is unlikely. In light of the remaining uncertainty in this area with regard to a discrete interval of deeper NAPL observed at MW-116DS and the unknown vertical extent of the wooden bulkhead, additional investigation is currently being conducted, as part of the SRI. However, the remedial alternative development, evaluation, and selection conservatively assume that the potential for NAPL migration between OU1 and OU2 should be addressed at NZ-2.	HIGH: NAPL containing COCs is present at depths posing a risk of direct contact, and NAPL is present adjacent to the Hudson River (ecological receptors).	HIGH: NAPL containing COCs is present at depths posing a risk of vapor intrusion.	Yes - Mobility and Toxicity Potential
NZ-3	LOW: NAPL in NZ-3 has low viscosity and has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 feet bgs. Gravitational forces and the impermeability and surface topography of the confining layer prevent further downward and lateral migration of NAPL in this zone.	LOW: NAPL contains COCs; however, depth limits potential for direct contact.	LOW: Depth of NAPL limits potential for vapor migration.	No
NZ-4	TO BE DETERMINED: NZ-4 consists of NAPL beneath Block 93 Central, Block 93 South, River Road, and the northwestern portion of the former Lever Brothers property. Potential migration of NAPL in NZ-4 is being determined as part of the ongoing OU1 SRI.	LOW: NAPL contains COCs; however, depth limits potential for direct contact.	LOW: Depth of NAPL limits potential for vapor migration.	Maybe - Dependant on results from SRI
NZ-5	CONSERVATIVELY ASSUMED HIGH: The available evidence supports the conclusion that most NAPL in this area is residual. However, due to the proximity of the NAPL to the Hudson River and the presence of sheens at OU2 near NZ-5, the remedial alternative development and evaluation conservatively assume that the potential for NAPL migration between OU1 and OU2 should be addressed at NZ-5.	MODERATE: NAPL present adjacent to the Hudson River (ecological receptors); however, depth limits potential for direct contact.	LOW: Depth of NAPL limits potential for vapor migration.	Yes - Mobility and Toxicity Potential
Tar Boils	LOW: Solid, taffy-like tar in the near surface vadose zone has been observed to seep through surface cracks in soil or pavement on very hot days. However, this very high viscosity material is not present in quantities sufficient to migrate beyond the immediate vicinity of the tar boil.	HIGH: Coal tar is present at the ground surface, posing a risk of direct contact.	HIGH: The presence of buildings would prevent the heating caused by sunlight that create this phenomenon. However, if a building were to be built atop existing tar boils, there would be a risk of vapor intrusion	Yes - Toxicity Potential
HCAA (Celotex)	LOW: Source material (pyritic ore) is not mobile.	LOW: Oxidizing pyritic waste material contains arsenic above applicable soil standards, however, the depth of the material limits the potential for direct contact.	LOW: Arsenic is not a vapor intrusion concern	No
HCAA (Quanta)	LOW: Source material (pyritic ore) is not mobile.	HIGH: Surface soil contains arsenic at concentrations posing an estimated Excess Lifetime Cancer Risk of 1×10^{-3} and a Hazard Index of 9, based on an exposure point concentration of 3,900 mg/kg. ^{2,3}	LOW: Arsenic is not a vapor intrusion concern	Yes - Toxicity Potential
HCAA (Block 93 North)	LOW: Source material (pyritic ore) is not mobile.	HIGH: Surface soil contains arsenic at concentrations posing an estimated Excess Lifetime Cancer Risk of 3×10^{-4} and a Hazard Index of 2, based on an exposure point concentration of 913 mg/kg. ^{2,3}	LOW: Arsenic is not a vapor intrusion concern	Yes - Toxicity Potential

NAPL Zone 4

NZ-4 comprises two layers of NAPL: one between 10 and 15 feet bgs and one between approximately 20 and 30 feet bgs. NZ-4 is located beneath Block 93 Central, Block 93 South, River Road and the northwestern portion of the former Lever Brothers property. The potential for mobility of NAPL in NZ-4 is being determined as part of the ongoing SRI.

NAPL Zone 5

At NZ-5, some evidence supports the conclusion that most NAPL in this area is residual (unable to flow). However the presence and nature of the connection between OU1 and OU2 at NZ-5 is being refined based on the results of the SRI. Due to the proximity of the NAPL to the Hudson River and the presence of sheens at OU2 near NZ-5, the remedial alternative development, evaluation, and selection address potential migration at NZ-5. This material is considered a principal threat waste.

Tar Boils

Solid, black, soft-to-stiff, semiplastic-to-plastic tar in the near surface vadose zone has been observed to seep upward to the ground surface through cracks in soil or pavement on very hot days. However, this highly viscous material is not present in quantities sufficient to migrate beyond the immediate vicinity of the tar boil.

High-Concentration Arsenic Area (Former Celotex)

The HCAA on the former Celotex property contains oxidizing pyritic material; however, this material is solid (immobile).

High-Concentration Arsenic Area (Quanta and Block 93 North)

The HCAA on the Quanta and Block 93 North properties contains oxidizing pyritic material; however, this material is solid (immobile).

1.7.2 Toxicity Potential

Toxicity potential was evaluated as consisting of two subcategories: (1) accessibility or proximity to human receptors at OU1 or ecological receptors at OU2 and (2) the potential for vapor intrusion. Highly toxic source material would represent a significant potential risk based on characteristics of the material and based on the exposure potential of the material (e.g., greater than 10^{-3} ELCR).

Accessibility/Proximity to Receptors

The accessibility of source material to human receptors at OU1 was evaluated on the basis of the depth of constituents. Source material greater than 10 feet bgs is considered inaccessible, reflecting the fact that no exposure scenarios are present for constituents at this depth (CH2M HILL, 2007).

The proximity of source material to ecological receptors in OU2 was evaluated on the basis of the distance from the Hudson River shoreline. Inland surface soil or COCs adjacent to the shoreline (regardless of depth) have been determined to have a higher toxicity potential than deeper inland COCs or COCs at greater distances from OU2.

Vapor Intrusion

The potential for source material to represent a source of toxicity potential based upon the potential for a completed vapor intrusion pathway to exist was evaluated based on analytical results, or where testing was not performed, the depth of, source material, molecular weight, and the presence and characteristics of buildings, if any.

Area-Specific Potential Toxicity Evaluation

NAPL Zone 1. The toxicity potential for source material at NZ-1 was determined to be high. NAPL is present at shallow depths and poses a potential direct contact risk. However, vapor intrusion investigations at 115 River Road have demonstrated that there is no existing unacceptable risk due to vapor intrusion. Vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or have been determined not to pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008a). This material is considered a principal threat waste.

NAPL Zone 2. The toxicity potential for source material at NZ-2 was determined to be high. NAPL is present in shallow soil, posing a potential risk through direct contact to receptors at OU1. In addition, NZ-2 is adjacent to the Hudson River. There exist no complete vapor intrusion pathways at NZ-2. This material is considered a principal threat waste.

NAPL Zone 3. Source material at NZ-3 is greater than 10 feet bgs and is therefore inaccessible to receptors at OU1. NZ-3 is not adjacent to the Hudson River. The molecular weight and depth of the zone indicate a lower potential for vapor intrusion. Therefore the potential toxicity of material at NZ-3 was determined to be low.

NAPL Zone 4. The toxicity potential for source material at NZ-4 has yet to be determined. The RI results indicate that the NAPL is present at 10 or more feet bgs, which contributes to a determination of low toxicity potential for this zone. Evaluation of the presence of NAPL in this zone is ongoing as part of the SRI.

NAPL Zone 5. The toxicity potential for source material at NZ-5 was determined to be moderate. Although residual NAPL is deep enough below ground surface to preclude direct contact, NZ-5 is adjacent to the Hudson River. There exist no complete vapor intrusion pathways at NZ-5. This material is considered a principal threat waste.

Tar Boils. Solid, black, soft-to-stiff, semiplastic-to-plastic tar in the near-surface vadose zone has been observed to seep through surface cracks in soil or pavement on very hot days. Direct contact with this material is expected to exceed acceptable risk levels (CH2M HILL, 2007). This material is considered a principal threat waste.

High-Concentration Arsenic Area (Former Celotex). At the portion of the HCAA on the former Celotex property, toxicity potential was determined to be low. Oxidizing pyritic waste material contains arsenic above applicable soil standards; however, the depth of the material reduces the potential for direct contact.

High-Concentration Arsenic Area (Quanta and Block 93 North). At the portion of the HCAA on the Quanta property, toxicity potential was determined to be high. Surface soil contains arsenic at concentrations posing an estimated ELCR of 1×10^{-3} and an HI of 9, based on an

exposure point concentration of 3,900 mg/kg (CH2M HILL, 2007). This material is considered a principal threat waste.

1.7.3 Conclusions

Of the eight areas containing source material, the following are addressed in this FS as principal threats: NAPL Zones 1, 2, and 5; tar boils; and the portion of the HCAA on the Quanta property and Block 93 North. This is based on toxicity potential at NZ-1, the tar boils, and the HCAA on the former Quanta property and Block 93 North and toxicity and mobility potential at NZ-2 and NZ-5. Source materials in NZ-3 and the portion of the HCAA on the former Celotex property are considered low-level threat waste, because both areas have been shown to pose low potential for toxicity or mobility, as described above. The evaluation of source material toxicity and mobility potential is summarized in Table 1-4. Whether NZ-4 is a principal threat area has yet to be determined and will be based on the results of the SRI and addressed in the draft final FS report. The alternatives presented in this FS are evaluated with respect to the principal threat waste criteria in Section 5.2.2.

SECTION 2

Development and Identification of ARARs, RAOs, and PRGs

The site has been characterized and is well understood for the purposes of supporting OU1 remedial alternative development, evaluation, and selection (CH2M HILL, 2008a). The extent of OU1 contamination for groundwater, soil, and NAPL based on the data and evaluations presented in the RI is shown in Figure 1-5. Additional work has been proposed as part of the SRI (CH2M HILL, 2008b) to address data gaps noted in the RI report. The results of this investigation will be presented in an SRI report for OU1 and will be incorporated into the draft final FS report. As stated in the RI report, the next step is to complete the development and evaluation of OU1 remedial alternatives. Based on the RI findings, the FS for OU1 should evaluate technologies and develop and screen remedial alternatives to

- Reduce current and/or potential future human health risks to acceptable levels at the properties comprising OU1, including mitigating potential future contact with NAPL
- Prevent erosion, transport, or migration of COCs in soil or groundwater offsite or to OU2 at concentrations resulting in human or ecological risk above acceptable levels

RAOs and PRGs were development and/ or identified during the development of the FS. They have separate objectives in so far as RAOs provide a general description of what the cleanup will accomplish while PRGs are the more-specific statements of the desired endpoint concentration or risk levels for each exposure route that are believed to adequately protect human health and the environment. Based on consideration of factors during the nine-criteria analysis and using PRGs as a point of departure, final cleanup levels may reflect different risk levels within an acceptable risk range than the originally identified PRGs. Final cleanup levels will be specified in the draft final FS report and documented in the ROD.

The following subsections describe the process of identifying ARARs and developing specific RAOs and PRGs to achieve these objectives

2.1 Summary of Applicable or Relevant and Appropriate Requirements

Remedial actions must protect human health and the environment. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements, as well as to adequately protect human health and the environment.

Definitions of the ARARs and the "to be considered" (TBC) criteria are as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, environmental action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, that while not “applicable,” address problems or situations sufficiently similar (relevant) to those encountered at a CERCLA site for their use to be well suited (appropriate) to the particular site.
- TBC criteria are nonpromulgated, nonenforceable guidelines or criteria that may be useful for developing an interim remedial action or are necessary for evaluating what protects human health and/or the environment. Examples of TBC criteria include EPA Drinking Water Health Advisories, Reference Doses, and Cancer Slope Factors.

Another factor in determining the requirements that must be addressed by the remedial alternatives is whether the requirement is substantive or administrative. “Onsite” CERCLA response actions must comply with the substantive requirements but not with the administrative requirements of environmental laws and regulations as specified in the NCP and in 40 CFR 300.5 and as discussed in 55 FR 8756. Substantive requirements are those pertaining directly to actions or conditions in the environment. Administrative requirements are mechanisms that facilitate the implementation of the substantive requirements of an environmental law or regulation. In general, administrative requirements prescribe methods and procedures (e.g., fees, permitting, inspection, and reporting requirements) by which substantive requirements are made effective for the purposes of a particular environmental or public health program.

ARARs are grouped into one of three types: chemical-specific, action-specific, and location-specific. Chemical-specific, action-specific, and location-specific ARARs for the site are summarized in Appendix A.

2.1.1 Chemical-Specific ARARs

Chemical-specific ARARs include laws and requirements that establish health- or risk-based numerical values or methodologies for environmental constituent concentrations or discharge. The chemical-specific ARARs for the site can be classified into one of three categories: (1) target cleanup objectives that define the residual concentrations of constituents that may remain at the site without presenting a threat to human health and the environment, (2) land disposal restriction concentrations that must be achieved if the contaminated medium contains a characteristic hazardous waste or contains a listed hazardous waste and is excavated or extracted and later land disposed, and (3) effluent concentrations that must be achieved in treatment of groundwater for discharge to surface water or groundwater. These three classifications are discussed below.

Residual Concentrations

For soil, the NJDEP soil remediation standards in NJAC 7:26D are ARARs for residual concentrations. The standards include the Residential Direct Contact Soil Remediation

Standards and the Non-Residential Direct Contact Soil Remediation Standards. EPA Region 9 PRGs are TBC for the site.

For groundwater, the NJDEP groundwater quality criteria (NJAC 7:9-6), the Safe Drinking Water Act maximum contaminant levels (MCLs), and the New Jersey Secondary Drinking Water Standards (NJAC 7:10-7) are ARARs for residual concentrations.

Land Disposal Restriction Considerations

The Resource Conservation and Recovery Act (RCRA) land disposal restrictions would apply to remedial actions performed at the site if waste generated by the remedial action (e.g., contaminated soil) contained a RCRA hazardous waste. Listed hazardous wastes as defined by RCRA regulation are not known to have been released at the site. As a result, excavated soils would not be required to be managed as listed hazardous wastes. If excavated and removed from the area of contamination (i.e., the soil is "generated"), the soil may be a characteristic hazardous waste if it exhibits one of the four characteristics defined in 40 CFR Part 261 Subpart C: ignitability, corrosivity, reactivity, or toxicity.

The waste likely to be generated during remediation at the site consists of recovered NAPL, excavated soil containing residual NAPL or other constituents, and recovered groundwater. Free-phase NAPL and soil containing NAPL may be characteristic wastes exhibiting toxic characteristics. Both soil containing residual NAPL and soil containing high concentrations of arsenic will likely fail the Toxicity Characteristic Leaching Procedure (TCLP), which is required to determine requirements for disposal.

Generated soils that exceed the TCLP limit must be managed as a hazardous waste and must meet the land disposal restriction treatment standards for contaminated soil (40 CFR 268.49). The treatment standard for contaminated soil is the higher value of a 90 percent reduction in constituent concentrations or 10 times the universal treatment standards. Treatment is required for the constituent for which the soil is a characteristic hazardous waste as well as other "underlying hazardous constituents." Generators of contaminated soil can apply reasonable knowledge of the likely contaminants present to select constituents for monitoring (EPA, 1998).

Effluent Standards

For water generated during remedial actions, specific groundwater discharge requirements are necessary for the disposal of water after treatment. The two main effluent standards that are applicable, as established by NJDEP, are the following:

- **Discharge to groundwater:** Reinjecting treated groundwater to the aquifer. The discharge-to-groundwater limit for the site must meet Class IIA groundwater criteria. NJDEP will require a New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Groundwater Permit (NJAC 7:14A-7) to allow for a discharge to groundwater.
- **Discharge to surface water:** Discharging treated groundwater to a surface water body. The surface water quality standard effluent limits for the site must meet the surface water criteria for the Hudson River classification. Surface water in the Hudson River adjacent to the Quanta site is classified as "SE2" according to the Surface Water Quality Standards, NJAC 7:9B (Hudson River [Englewood Cliffs]—river and saline portions of

New Jersey tributaries from the confluence with the Harlem River, N.Y., to a north-south line connecting Constable Hook [Bayonne, N.J.] to St. George [Staten Island, N.Y.]). SE2 refers to saline estuarine waters' with designated uses listed in NJAC 7:9B-1.12(e). NJDEP will require an NJPDES Discharge to Surface Water Permit (NJAC 7:14A-11 through 13) to allow for a discharge to surface water.

2.1.2 Action-Specific ARARs

Action-specific ARARs regulate the specific type of action or technology under consideration or the management of regulated materials. The most important federal action-specific ARAR that may affect the RAOs and the development of remedial action alternatives is RCRA. RCRA regulations governing the identification, management, treatment, storage, and disposal of solid and hazardous waste would be ARARs for alternatives generating waste that would be moved to a location outside the area of contamination. Requirements are for waste accumulation, record-keeping, container storage, manifesting, transporting, and disposal. As discussed above, soil at the site may be a characteristic hazardous waste. If any generated soil is a characteristic hazardous waste, RCRA land disposal restrictions would apply, and treatment would be required in accordance with RCRA prior to disposal. This also includes treatment of other underlying hazardous constituents as required by 40 CFR 268.9(a).

There are also specific state requirements, including the Technical Requirements for Site Remediation (NJAC 7:26E), and other applicable state regulations that are action-specific ARARs for the site, such as wastewater discharge requirements (NJAC 7:9-5.1).

2.1.3 Location-Specific ARARs

Location-specific ARARs are requirements that relate to the geographical position of the site. State and federal laws and regulations that apply to the protection of wetlands, construction in floodplains, and protection of endangered species in streams or rivers are examples of location-specific ARARs. Location-specific ARARs that may be applicable to the remedial activities, depending on the remedial action selected, are the following:

- Coastal Area Facility Review Act Permit (New Jersey Statutes Annotated [NJSA] 13:19-1 et seq.)
- Waterfront Development/Upland Waterfront Permit (NJSA 12:5-3)
- Flood Hazard Area Control Act (NJAC 7:13)
- Wetlands Permit (NJSA 13:9A-1)
- Deed Notice (NJSA 58:10B-13)
- Freshwater Protection Act (NJSA 13:9B-1)
- Stream Encroachment Permit (Construction Within a Flood Plain) (NJSA 58:16A-50 et seq.; NJAC 7:8-3.15)

2.2 Remedial Action Objectives

EPA's (1988b) *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites* and the NCP define RAOs as medium-specific or site-specific goals for protecting human health and the environment. The RAOs are established on the basis of the nature and extent of the contamination, the receptors that are currently and potentially threatened, and the

potential for human and environmental exposure. Remediation goals are site-specific, quantitative goals that define the extent of cleanup required to achieve the RAOs. These goals are PRGs in the FS, and they will be finalized in the ROD for the site. In this section, the RAOs have been developed for media at OU1. RAOs have been based on the exposure pathways found during the human health risk assessment (HHRA) to present unacceptable risks.

Nine RAOs were identified (four for principal threat waste, three for low-level threat waste, and two for groundwater) to mitigate the potential risks associated with the site (Table 2-1). These RAOs were originally presented in a May 14, 2007, meeting with EPA and NJDEP. Below is a summary of the RAOs developed for the site, with slight modifications made on the basis of the May meeting, subsequent discussions, and EPA's April 2008 letter to Honeywell (EPA, 2008).

TABLE 2-1
Remedial Action Objectives
Quanta Resources Superfund Site, OU1, Edgewater New Jersey

Remedial Action Objective	
Principal Threats	
1	Remove, treat or contain free product, pursuant to NJAC 7:26E-6.1(d).
2	Prevent human exposure to NAPL and arsenic source material that poses human health risk in excess of 10^{-3} ELCR.
3	Prevent current or potential future migration of free-phase NAPL to the Hudson River or to areas that would result in direct contact exposure.
4	Prevent migration of source material that poses a potential source of vapor intrusion and resulting inhalation exposure within existing or potential future structures, to the extent practicable.
Low Level Threat Source Material	
1	Prevent/minimize potential human exposure through contact, ingestion, inhalation (dust), or vapor intrusion that presents unacceptable risk
2	Prevent/minimize potential erosional transport off-site or to OU2 of Site COCs at concentrations posing unacceptable risk
3	Remove, treat or contain free and residual product, pursuant to NJAC 7:26E-6.1(d).
Groundwater	
1	Prevent/minimize potential exposure by contact, ingestion, inhalation/vapor intrusion that presents unacceptable risk
2	Prevent migration and preferential flow of COCs to OU2 at levels resulting in risk above acceptable levels to human health or ecological receptors.

2.2.1 RAOs for Principal Threats

These RAOs for source material are intended to address the principal threats discussed in Section 1.10:

- Remove, treat, or contain free product pursuant to NJAC 7:26E-6.1(d)
- Prevent human exposure to NAPL and arsenic source material that poses human health risk in excess of 10^{-3} ELCR
- Prevent current or potential future migration of free-phase NAPL to the Hudson River or to areas that would result in direct contact exposure
- Prevent migration of NAPL that poses a potential source of vapor intrusion and resulting inhalation exposure within existing or potential future structures, to the extent practicable

Each of these RAOs is discussed in further detail below:

Remove, Treat, or Contain Free Product

This RAO is intended to address source material determined to pose a principal threat due to potential mobility.

Prevent Human Exposure to Principal Threat Waste

Exposure to accessible source materials (i.e., tar boils, shallow free-phase NAPL, or soil in the HCAA) through direct contact, ingestion, or inhalation is not likely to occur under existing conditions. The undeveloped portion of the site is currently unoccupied and fenced. The developed area of the site currently has existing engineering controls (building foundations and paved parking areas) that eliminate direct contact and/or ingestion. The results of vapor intrusion studies conducted during the RI conclude that the vapor intrusion pathways are unlikely to be present or are of a sufficiently small magnitude such that they do not pose an unacceptable human health risk to current receptors. There is, however, the potential that redevelopment of the site may result in potential exposure if appropriate remedial actions are not implemented. This RAO is intended to mitigate potential risks to potential future industrial or excavation workers as a result of exposure to highly toxic source material at the site.

Prevent Current or Potential Future Migration of Free-Phase NAPL to the Hudson River or to Areas That Would Result in Direct Contact Exposure

Without additional remedial effort, there is the potential for the migration of free-phase NAPL to surface water and sediment in the Hudson River. This RAO is intended to prevent unacceptable risks in surface water and sediment through potential migration of free-phase NAPL to OU2.

Prevent Migration of NAPL That Poses a Potential Source of Vapor Intrusion

Without additional remedial effort, there is the potential for the migration of shallow free-phase NAPL to areas with existing or potential future buildings. This RAO is intended to prevent potential future unacceptable risks as a result of vapor intrusion.

2.2.2 RAOs for Low-Level Threat Waste

There is a potential for exposure to low-level threat waste by receptors (e.g., construction/utility workers, commercial workers, daycare children, and residents) that

may present an unacceptable risk under existing and/or future conditions if not addressed appropriately by the remedial action selected for the site. A primary objective of this FS is to develop alternatives that will mitigate potential risks to onsite receptors. In addition, contaminated soil at the site may contribute to the presence of COCs in groundwater, surface water, and sediment through potential migration. Consequently, an additional objective for remediation of the contaminated soil is to allow the RAOs for groundwater, surface water, and sediment remediation to be met.¹⁰

The RAOs for remediation of low-level threat waste at the site include the following:

- Prevent/minimize potential human exposure through contact, ingestion, dust inhalation, or vapor intrusion that presents unacceptable risk
- Prevent/minimize potential erosional transport offsite or to OU2 of site COCs at concentrations posing unacceptable risk
- Remove, treat, or contain free and residual product, pursuant to NJAC 7:26E-6.1(d)

Each of these RAOs is discussed in further detail below:

Prevent/Minimize Potential Human Exposure Through Contact, Ingestion, Inhalation (Dust), or Vapor Intrusion That Presents Unacceptable Risk

Exposure to contaminated soil through direct contact, ingestion, or inhalation is not likely to occur under existing conditions since the undeveloped portion of the site is currently unoccupied and fenced. The developed area of the site has existing engineering controls (building foundations and paved parking areas) that eliminate direct contact or ingestion. The results of vapor intrusion studies conducted during the RI conclude that the vapor intrusion pathways are unlikely to be present or are of a magnitude sufficiently small that they do not pose an unacceptable human health risk to the occupants of these buildings under current conditions. There is, however, the potential that redevelopment of the site may result in potential exposure to COCs in soil if appropriate remedial actions are not implemented. This RAO is intended to prevent unacceptable risks to potential future industrial or excavation workers as a result of exposure to contaminated soil at the site.

Prevent/Minimize Potential Transport Offsite or to OU2 of Site COCs at Concentrations Posing Unacceptable Risk

Possible erosion of surficial soil not covered with asphalt, concrete paving, or vegetation could result in the offsite migration of COCs at concentrations posing unacceptable risks through direct contact and ingestion. Although this potential risk is minimal under existing conditions, if future use dictates the need to remove the existing covers, erosion and transport could occur. This RAO is intended to prevent unacceptable risks to offsite receptors as a result of exposure to contaminated soil.

Remove, Treat, or Contain Free and Residual Product

This RAO is intended to address New Jersey requirements concerning free and residual product (NJAC 7:26E-6.1(d)). The range of remedial alternatives addresses potential

¹⁰ Surface water and sediment remediation goals will be discussed as part of the FS for OU 2.

exposure through a combination of removal, treatment, or containment as practicable and appropriate.

2.2.3 RAOs for Groundwater

The RAOs for groundwater at the site were developed to minimize further migration of the contaminant plume and mitigate impacts to the downgradient receptors. The RAOs for remediation of groundwater at the site include the following:

- Prevent/minimize potential exposure by contact, ingestion, or inhalation/vapor intrusion that presents that presents unacceptable risk
- Prevent migration and preferential flow of COCs to OU2 at levels resulting in risk above acceptable levels to human health or ecological receptors

Each of these RAOs is discussed in further detail below:

Prevent/Minimize Potential Exposure by Contact, Ingestion, or Inhalation/Vapor Intrusion That Presents Unacceptable Risk

Exposure to contaminated groundwater through direct contact, ingestion, or inhalation is not likely to occur since groundwater is not used as source of potable water in this area. There is, however, a potential for redevelopment of the site that may result in exposure to impacted groundwater if additional remedial efforts are not taken. This RAO is intended to prevent unacceptable risks to potential future industrial or excavation workers as a result of exposure to contaminated groundwater at the site.

Prevent Migration and Preferential Flow of COCs to OU2 at Levels Posing Unacceptable Risk

Without an additional remedial effort, there is the potential for groundwater constituents to migrate to surface water and sediment in the Hudson River. This RAO is intended to prevent unacceptable risks in surface water and sediment through migration of groundwater constituents.

2.3 Preliminary Remediation Goals

To meet the RAOs defined in Section 2.2, PRGs were developed to aid in defining the extent of contaminated media requiring remedial action. This section presents the PRGs that will be addressed in the FS process. In general, PRGs establish media-specific concentrations of COCs that will pose no unacceptable risk to human health and the environment. COCs are those chemicals that result in unacceptable risk based on the results of the BHHRA. The PRGs are developed taking the following into consideration:

- Chemical-specific ARARs or TBCs, including applicable New Jersey remediation standards, groundwater quality criteria, and federal MCLs
- Concentration levels corresponding to an excess cancer risk between 1×10^{-4} and 1×10^{-6} , a chronic health risk defined by an HI of 1, or a significant ecological risk
- Factors related to technical limitations, uncertainties, and other pertinent information

TABLE 2-2
Summary of Soil Preliminary Remediation Goals (PRGs)
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent of Concern	Risk Based PRGs (10 ⁻⁶ to 10 ⁻⁴ or HQ=1)		NJ Soil Standard (Residential)	NJ Soil Standard (Non-Residential)	PRG	Basis for PRG	Comments
Surface Soil							
2-Methylnaphthalene	304	304	230	2,400	230	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
4-Methylphenol	380	380	31	340	31	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Antimony	31	31	31	450	31	RSS / HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Aroclor-1242	0.2	1.0	0.2	1.0	0.2	RSS / HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Aroclor-1254	0.2	1.0	0.2	1.0	0.2	RSS / HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Aroclor-1260	0.2	1.0	0.2	1.0	0.2	RSS / HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Arsenic	0.39	22	19	19	0.39	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzene	11	304	2	5	2	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(a)anthracene	0.6	60	0.6	2	0.6	RSS / ELCR	NJ Residential Soil Standard equals the risk-based concentration.
Benzo(a)pyrene	0.06	6.2	0.2	0.2	0.06	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzo(b)fluoranthene	0.62	62	0.6	2	0.6	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(k)fluoranthene	6.2	620	6	23	6	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Carbazole	31	3,096	24	96	24	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Chromium	132	210	NA	NA	132	HQ	NJ Soil Standards for chromium are not available
Chrysene	62	6,204	62	230	62	RSS / ELCR	NJ Residential Soil Standard equals the risk-based concentration.
Copper	3,120	3,120	3,100	45,000	3,100	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Dibenzo(a,h)anthracene	0.06	6.0	0.2	0.2	0.06	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Fluorene	2,294	2,294	2,300	24,000	2,294	HQ	Risk-based concentration is lower than the NJ Soil Standards
Heptachlor	0.14	14	0.1	0.7	0.1	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Indeno(1,2,3-cd)pyrene	0.62	62	0.6	2	0.6	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Iron	23,399	23,399	NA	NA	23,399	HQ	NJ Soil Standards for iron are not available
Lead	400	400	400	800	400	RSS / HQ	NJ Residential Soil Standard equals the risk-based concentration.
Mercury	23	23	23	65	23	RSS / HQ	NJ Residential Soil Standard equals the risk-based concentration.
Naphthalene	1,146	1,146	6	17	6	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Thallium	5	5	5	79	5	RSS / HQ	NJ Residential Soil Standard equals the risk-based concentration.
Xylenes, Total	71	71	12,000	170,000	71	HQ	Risk-based concentration is lower than the NJ Soil Standards
Vanadium	15,211	15,211	78	1100	78	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Zinc	23,399	23,399	23,000	110,000	23,000	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.

TABLE 2-2
Summary of Soil Preliminary Remediation Goals (PRGs)
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent of Concern	Risk Based PRGs (10 ⁻⁶ to 10 ⁻⁴ or HQ=1)		NJ Soil Standard (Residential)	NJ Soil Standard (Non- Residential)	PRG	Basis for PRG	Comments
Subsurface Soil							
2-Methylnaphthalene	1,203	1,203	230	2,400	230	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Antimony	121	121	31	450	31	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Arsenic	0.34	13	19	19	0.34	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzene	382	382	2	5	2	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(a)anthracene	21	2,100	0.6	2	0.6	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(a)pyrene	2.0	200	0.2	0.2	0.2	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(b)fluoranthene	21	2,100	0.6	2	0.6	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Dibenzo(a,h)anthracene	2.0	200	0.2	0.2	0.2	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Indeno(1,2,3-cd)pyrene	21	2,100	0.6	2	0.6	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Iron	92,631	92,631	NA	NA	92,631	HQ	NJ Soil Standards for iron are not available
Lead	618*	618*	400	800	400	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Naphthalene	4,247	4,247	6	17	6	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Thallium	20	20	5	79	5	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.

All concentrations presented in mg/kg.
COCs defined as contributing a chemical-specific ELCR>1E-6 or HI>0.1 when receptor total ELCR (all soil pathways) >1E-6 or HI>1.0.
Risk-Based PRGs are the lower of the concentrations at which each constituent poses risk within the 10⁻⁴ to 10⁻⁶ risk range or has a HQ of 1, and were developed as part of the Draft Baseline Human Health Risk Assessment.
Surface soil risk-based remedial goals were calculated using exposure factors for an aggregate resident. Remedial goals for chemicals with a mutagenic mode of action (benzo(a)pyrene and dibenz(a,h)anthracene) were calculated using exposure factors for the aggregate age group with the highest risk.
Subsurface soil risk-based remedial goals were calculated using exposure factors for a construction worker.
PRGs may be revised based on the outcome of discussions with EPA and NJDEP regarding background concentrations of COCs in the vicinity of the Site.
* Calculated using the Adult Lead Methodology
HQ - Hazard Quotient
ELCR - Excess Lifetime Cancer Risk
NA - Not Applicable or Not Available
RSS - NJ Residential Soil Standard - New Jersey Residential Direct Contact Soil Remediation Standard (NJAC 7:26D)
NJ Non-Residential Soil Standard - New Jersey Non-Residential Direct Contact Soil Remediation Standard (NJAC 7:26D)

Below is a summary of the PRGs for soil and groundwater established for OU1.

2.3.1 PRGs for Soil

Risk-based soil PRGs were developed based on the potential exposure risks and the RAOs as part of the BHHRA for ingestion, dermal contact, and inhalation human health exposure pathways. The human health exposure pathways that have been evaluated included both residential and nonresidential exposures. Soil PRGs were selected as the lowest of these risk-based concentrations, and New Jersey Soil Remediation Standards¹¹ were selected for residential and nonresidential land use. Where a remediation standard is not available, the risk-based concentration corresponding to an ELCR of 1×10^{-4} or an HI of 1 was selected. EPA (2004) Region 9 PRGs, which cover the full risk range (1×10^{-4} to 1×10^{-6} ELCR), were also evaluated as TBCs. Soil PRGs are presented in Table 2-2.

2.3.2 PRGs for Groundwater

PRGs were developed for groundwater based on the RAOs discussed earlier. The minimum concentration of the EPA federal MCLs, NJDEP groundwater quality criteria, and risk-based concentrations developed as part of the BHHRA was selected as the PRG. EPA (2004) Region 9 Tap Water PRGs were evaluated as TBCs. The PRGs for groundwater are listed in Table 2-3.

2.4 Media Exceeding PRGs

2.4.1 Horizontal Extent

The maximum extent of soil and groundwater impacts associated with OU1 (including the presence of free and residual NAPL) has been delineated and is depicted in Figure 1-5. The northern boundary of OU1 is defined by the extent of NAPL and site-related constituents in subsurface soils and groundwater, as well as the area under the arsenic cap on the former Celotex property. The southern boundary of OU1 defines the extent of dissolved-phase site-related constituents (approximately the same as the location of a groundwater convergence on the northern portion of the former Lever Brothers property).

Pitch/asphaltic material in the fill throughout the former Lever Brothers property is not included within the extent of OU1 because it has not emanated from the Quanta site and is distinctly different from the NAPL that is found on the Quanta property and the northern portion of the former Lever Brothers property (depicted in Figure 1-5). At the southern boundary of OU1, the leading edge of dissolved-phase NAPL constituents is collocated with similar impacts related to documented source areas associated with former operations on the Lever Brothers property south of the groundwater convergence. To the west, the definitive extent of site-related impacts will be determined during the SRI. However, existing data suggest that site-related impacts in the area of Block 93 Central and South appear to be limited to the eastern portions of these properties.

¹¹ Source: <http://www.nj.gov/dep/srp/regs/rs/>, accessed September 9, 2008.

TABLE 2-3

Summary of Groundwater Preliminary Remedial Goals (PRGs)
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk Range for COCs in Shallow Groundwater (10^{-6} to 10^{-4} or HQ=1)		Site Background*	NJ GWQS (Class IIA)	NJ GWQS (Interim Generic)	SDWA MCL	PRG*	Basis for PRG
1,1'-Biphenyl	—	—	TBD	400	—	—	400	NJ GWQS (Class IIA)
1,1-Dichloroethane	—	—	TBD	50	—	—	50	NJ GWQS (Class IIA)
1,1-Dichloroethene	—	—	TBD	1	—	7	1	NJ GWQS (Class IIA)
1,2,4-Trichlorobenzene	—	—	TBD	9	—	70	9	NJ GWQS (Class IIA)
1,2-Dichloroethane	—	—	TBD	2	—	5	2	NJ GWQS (Class IIA)
2,4-Dimethylphenol	—	—	TBD	100	—	—	100	NJ GWQS (Class IIA)
2-Methylnaphthalene	4,328	4,328	TBD	—	100	—	100	NJ GWQS (Interim Generic)
2-Methylphenol	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
3&4-Methylphenol	—	—	TBD	—	5	—	5	NJ GWQS (Interim Generic)
4,4'- Dichlorodiphenyldichloroethane	—	—	TBD	0.1	—	—	0.1	NJ GWQS (Class IIA)
4,4'- Dichlorodiphenyldichloroethylene	—	—	TBD	0.1	—	—	0.1	NJ GWQS (Class IIA)
4,4'- Dichlorodiphenyltrichloroethane	—	—	TBD	0.1	—	—	0.1	NJ GWQS (Class IIA)
4-Methylphenol	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Acenaphthene	—	—	TBD	400	—	—	400	NJ GWQS (Class IIA)
Acenaphthylene	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Acetone	—	—	TBD	6,000	—	—	6,000	NJ GWQS (Class IIA)
Aldrin	—	—	TBD	0.04	—	—	0.04	NJ GWQS (Class IIA)
Alpha-BHC	—	—	TBD	0.02	—	—	0.02	NJ GWQS (Class IIA)

TABLE 2-3

Summary of Groundwater Preliminary Remedial Goals (PRGs)
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk Range for COCs in Shallow Groundwater (10^{-5} to 10^{-4} or HQ=1)		Site Background*	NJ GWQS (Class IIA)	NJ GWQS (Interim Generic)	SDWA MCL	PRG*	Basis for PRG
Alpha-Chlordane	—	—	TBD	0.05	—	—	0.05	NJ GWQS (Class IIA)
Ammonia	—	—	TBD	3,000	—	—	3,000	NJ GWQS (Class IIA)
Anthracene	—	—	TBD	2,000	—	—	2,000	NJ GWQS (Class IIA)
Aroclor-1260	—	—	TBD	0.5	—	—	0.5	NJ GWQS (Class IIA)
Arsenic	4,320	27,772	TBD	3	—	10	3	NJ GWQS (Class IIA)
Benzene	1,900	6,247	TBD	1	—	5	1	NJ GWQS (Class IIA)
Benzo(a)anthracene	10	1,000	TBD	0.1	—	—	0.1	NJ GWQS (Class IIA)
Benzo(a)pyrene	1	100	TBD	0.1	—	0.2	0.1	NJ GWQS (Class IIA)
Benzo(b)fluoranthene	5	500	TBD	0.2	—	—	0.2	NJ GWQS (Class IIA)
Benzo(g,h,i)perylene	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Benzo(k)fluoranthene	59	5,900	TBD	0.5	—	—	0.5	NJ GWQS (Class IIA)
Bis(2-ethylhexyl)phthalate	—	—	TBD	3	—	—	3	NJ GWQS (Class IIA)
Caprolactam	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Carbazole	—	—	TBD	—	5	—	5	NJ GWQS (Interim Generic)
Carbon Disulfide	—	—	TBD	700	—	—	700	NJ GWQS (Class IIA)
Chloroethane	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Chloromethane	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Chrysene	—	—	TBD	5	—	—	5	NJ GWQS (Class IIA)
Cis-1,2-dichloroethene	—	—	TBD	70	—	70	70	NJ GWQS (Class IIA) / SDWA MCL

TABLE 2-3

Summary of Groundwater Preliminary Remedial Goals (PRGs)
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk Range for COCs in Shallow Groundwater (10^{-6} to 10^{-4} or HQ=1)		Site Background*	NJ GWQS (Class IIA)	NJ GWQS (Interim Generic)	SDWA MCL	PRG*	Basis for PRG
Cyclohexane	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Delta-Benzenehexachloride	—	—	TBD	—	5	—	5	NJ GWQS (Interim Generic)
Dibenzo(a,h)anthracene	0.4	40	TBD	0.3	—	—	0.3	NJ GWQS (Class IIA)
Dibenzofuran	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Endosulfan Sulfate	—	—	TBD	40	—	—	40	NJ GWQS (Class IIA)
Endrin	—	—	TBD	2	—	2	2	NJ GWQS (Class IIA)
Ethylbenzene	—	—	TBD	700	—	700	700	NJ GWQS (Class IIA) / SDWA MCL
Fluoranthene	—	—	TBD	300	—	—	300	NJ GWQS (Class IIA)
Fluorene	—	—	TBD	300	—	—	300	NJ GWQS (Class IIA)
Gamma-BHC (Lindane)	—	—	TBD	0.03	—	0.2	0.03	NJ GWQS (Class IIA)
Heptachlor	—	—	TBD	0.05	—	0.4	0.05	NJ GWQS (Class IIA)
Heptachlor Epoxide	—	—	TBD	0.2	—	0.2	0.2	NJ GWQS (Class IIA) / SDWA MCL
Indeno(1,2,3-CD)pyrene	5	500	TBD	0.2	—	—	0.2	NJ GWQS (Class IIA)
Iron	—	—	TBD	300	—	—	300	NJ GWQS (Class IIA)
Isopropylbenzene	—	—	TBD	700	—	—	700	NJ GWQS (Class IIA)
Lead	—	—	TBD	5	—	15	5	NJ GWQS (Class IIA)
Methylcyclohexane	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Naphthalene	1,061	1,061	TBD	300	—	—	300	NJ GWQS (Class IIA)
Nitrobenzene	—	—	TBD	6	—	—	6	NJ GWQS (Class IIA)

TABLE 2-3

Summary of Groundwater Preliminary Remedial Goals (PRGs)
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk Range for COCs in Shallow Groundwater (10^{-6} to 10^{-4} or HQ=1)		Site Background*	NJ GWQS (Class IIA)	NJ GWQS (Interim Generic)	SDWA MCL	PRG*	Basis for PRG
O-Xylene	—	—	TBD	1,000	—	10,000	1,000	NJ GWQS (Class IIA)
Phenanthrene	—	—	TBD	—	100	—	100	NJ GWQS (Interim Generic)
Phenol	—	—	TBD	2,000	—	—	2,000	NJ GWQS (Class IIA)
Pyrene	—	—	TBD	200	—	—	200	NJ GWQS (Class IIA)
Styrene	—	—	TBD	100	—	—	100	NJ GWQS (Class IIA)
Tetrachloroethene	—	—	TBD	1	—	5	1	NJ GWQS (Class IIA)
Toluene	—	—	TBD	1,000	—	1,000	1,000	NJ GWQS (Class IIA)
Trichloroethene	—	—	TBD	1	—	—	1	NJ GWQS (Class IIA)
Vinyl Chloride	—	—	TBD	1	—	2	1	NJ GWQS (Class IIA)
Xylenes, M & P	—	—	TBD	1,000	—	10,000	1,000	NJ GWQS (Class IIA)
Xylenes, Total	—	—	TBD	1,000	—	10,000	1,000	NJ GWQS (Class IIA)

Notes:

**PRGs may be modified based on the outcome of the human health risk assessment for OU1, ecological risk assessment for OU2, and establishment of background concentrations of constituents in groundwater."

All concentrations presented in mg/L

ELCR - Excess Lifetime Cancer Risk

GWQS - Groundwater Quality Standards

HQ - Hazard Quotient

MCL - Maximum Contaminant Level

SDWA - Safe Drinking Water Act

PRG - Preliminary Remedial Goal

TBD - To be determined

COC - Constituent of Concern

OU1 - Operable Unit 1

OU2 - Operable Unit 2

2.4.2 Vertical Extent

Surface Soil

Soil within the range of 0 to 2 feet bgs on the Quanta and Block 93 North properties contains constituents released during former operations. These properties fall within the historical footprint of site operations. Non-site-related impacts to soil in the interval of 0 to 2 feet bgs are described below for each of the properties making up OU1.

- Limited impacts identified within the range of 0 to 2 feet bgs on the Block 93 Central property are most likely a result of rail activity and loading and unloading associated with former Spencer-Kellogg operations. However, minor erosion may have resulted in incidental transport of site-related constituents to this property. Soil within the range of 0 to 2 feet bgs on the Block 93 South property does not contain site-related constituents. Active operations between former site operations and Block 93 South have prevented the overland migration of site-related constituents between these areas.
- Soil currently within the interval of 0 to 2 feet bgs on the former Celotex property consists entirely of fill material imported during property redevelopment within the past several years; therefore, soil does not contain constituents that have migrated from operations at the site.
- Soil within the interval of 0 to 2 feet bgs on the 115 River Road property has the potential to have been impacted by former operations due to surficial transport of soil across the property boundary.
- Soil within the range of 0 to 2 feet bgs on the former Lever Brothers property does not contain site-related constituents. At all times during which historical maps and aerial photographs document active operations on the Quanta and former Celotex properties, operations documented or depicted on the 115 River Road property, between the Quanta and former Celotex properties, and on the former Lever Brothers property. Buildings and other surface improvements on these properties associated with historical operations would have physically prevented the direct overland migration of NAPL or surface soil from the northern properties to the surface of the former Lever Brothers property. Cinder investigation results confirm the lack of waste material on the northern portions of the former Lever Brothers property related to the former sulfuric acid plant operation.
- Soil within the range of 0 to 2 feet bgs within the footprint of River and Gorge roads consists of fill material imported during road construction in the 1990s and is elevated above the ground level of the former operations; therefore, these materials do not contain site-related constituents.

Subsurface Soil

Subsurface soil (greater than 2 feet bgs) has been impacted by free or residual NAPL or site-related constituents (including arsenic) to a maximum depth that corresponds to the top of the silty-clay confining unit (found as deep as 30 feet bgs). To the south and southwest, less-viscous coal tar has migrated vertically and has pooled in low-lying areas associated with the top of the silty clay. In the west, central, and eastern portions of OU1 (adjacent to the

bulkhead), more-viscous tars are less mobile and generally have reached only a depth of approximately 11 feet bgs.

Groundwater

Dissolved-phase COCs in groundwater are limited generally to the shallow overburden fill and native sand deposits overlying the silty-clay confining unit. Deep sand beneath the confining unit is impacted with chlorinated solvents that are the result of an unidentified offsite upgradient source unrelated to OU1. Low levels of PAHs and BTEX compounds (benzene, toluene, ethylbenzene, and xylenes) have been detected adjacent to the Hudson River in a sand layer below a thin layer of silty clay and at even lower concentrations in the central portion of OU1. The sand deposits in which these wells are screened are not believed to be connected to the "deep sand" because this formation pinches out against the rising bedrock surface to the north and is not present in these areas. These impacts are localized to this area and are the result of the migration of lower levels of these constituents in groundwater from the overlying shallow unit and the fact that the well screen at this deep sand location (MW-116DS) is partially screened within the silty clay at a depth of only several feet below the overlying shallow groundwater. The distribution of the deep sand in the shoreline areas and the extent of coal tar impacts observed within and above these deposits are being addressed as part of supplemental investigations.

2.5 Technical Impracticability

Technical impracticability (TI) evaluations are sought in order to waive specific ARARs when site-specific conditions make it infeasible to achieve those ARARs within a reasonable timeframe. As specified in the NCP, "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site" (NCP Section 300.430(1)(iii)F). However, as stated by EPA (1993), "experience over the past decade has shown that restoration to drinking water quality (or more stringent levels where required) may not always be achievable due to the limitations of available remediation technologies.... EPA, therefore, must evaluate whether ground-water restoration at Superfund and RCRA ground-water cleanup sites is attainable from an engineering perspective (p. 1)."

TI waivers document in the context of feasibility, reliability, and cost and from an engineering perspective the conditions that make it impracticable to achieve specific ARARs within a reasonable timeframe. TI waivers also lay out an alternative remedial strategy that will protect human health and the environment. TI waivers are most often implemented at sites with DNAPL. EPA (1995b) states that "OSWER [Office of Solid Waste and Emergency Response] expects that TI waivers will generally be appropriate for [DNAPL] sites...where technical, time, and cost limitations demand a more limited approach."

As described in the following subsections, restoration of groundwater at the site is technically impracticable as a result of contaminant-related factors in connection with the presence of arsenic in soil and groundwater and NAPL throughout the site. A TI waiver of specific ARARs is being requested, and alternative remedial goals are proposed in lieu of the waived ARARs. An alternative remedial strategy implemented under a CERCLA ARAR waiver would remain in effect as long as that strategy remains protective of human health

and the environment. At a minimum, when restoration of groundwater is not practicable, EPA expects to prevent further migration of the plume, prevent human exposure to the contaminated groundwater, and evaluate further risk reduction measures (40 CFR 300.430 (a)(1)(iii)F)).

2.5.1 Groundwater Restoration Potential

It is technically infeasible to achieve all drinking water standards for groundwater in a reasonable timeframe due to a number of factors, such as regional groundwater impacts unrelated to the Quanta site, that have resulted from the anthropogenic background (fill material) and the presence of the Hudson River as well as the presence of residual sources that are technologically infeasible to completely remediate.

Upgradient Sources

A currently unidentified source of chlorinated solvents upgradient of the site is contributing to the presence of chlorinated constituents in the deep, confined, sandy geologic unit where the presence of site-related constituents in groundwater is minimal. The absence of chlorinated solvents in the shallower unconfined zones of groundwater at the site and a consistently upward flow component between these units support the conclusion that these constituents do not originate from the site. Groundwater at the site cannot be remediated to applicable drinking water standards unless this offsite source is addressed.

Regional Historical Fill Material

As shown in Figure 2-1, the elevation of the site and surrounding area was raised through the importation of fill materials as part of reclamation efforts along the Hudson River during the 19th century. Extensive soil- and groundwater-sampling results from OU1 and surrounding properties indicate that the regional fill presently constitutes an ongoing source of metals and PAHs. These sources can result in groundwater concentrations of constituents in excess of applicable federal and state water quality standards (CH2M HILL, 2008a). Fill material both within and upgradient of the site contributes to regional groundwater degradation; therefore, even if all fill material were removed from OU1 and replaced with certified clean backfill, upgradient offsite fill material would remain and serve as a continuous source of COCs to groundwater. Groundwater at the site cannot be remediated to applicable drinking water standards unless offsite sources are addressed.

Hydrogeologic Factors

Hydrogeologic characteristics limit the potential for groundwater restoration. The subsurface at the site comprises heterogeneous silt and clays and interbedded fill material that is representative of a typical floodplain setting along a major tidal estuary. Variation in conductivity both laterally and vertically at the site would restrict the effectiveness of in situ treatment that would require the thorough distribution of reactants. Similarly, extraction technologies are not expected to effectively draw groundwater containing COCs from areas of concern; rather, groundwater will be drawn preferentially from higher conductivity zones. As shown in the RI report (CH2M HILL, 2008a), groundwater at the site is tidally influenced, adding to the complication of effective extraction or in situ treatment.

Presence of NAPL

The location, nature, and extent of most of the NAPL at OU1 have been defined. The current understanding of NAPL location will be supplemented during the evaluation of the results of the SRI (CH2M HILL, 2008a). As EPA (1993) states, DNAPLs “often are particularly difficult to locate and remove from the subsurface; their ability to sink through the water table and penetrate deeper portions of aquifers is one of the properties that makes them very difficult to remediate.... [M]ost of the sites where EPA already has determined that ground-water restoration is technically impracticable have DNAPLs present” (p. 2).

The majority of NAPL at the site is present as part of one of four discrete NAPL zones (NZ-1, 2, 3, and 4). An additional zone (NZ-5) was identified on the basis of its proximity to the Hudson River and on the need to evaluate these impacts for the purpose of the remedy selection process. Outside the NAPL zones, hard tars or thin layers of residual NAPL are present at various locations within the area shown in Figure 1-5 as the lateral extent of NAPL. The extent of residual and free-phase NAPL and the variability of NAPL properties at the site complicate the selection of remedial strategies for this material. If remedial strategies were selected to address all NAPL within the NAPL zones, residuals remaining after treatment or small undetected pockets of residual NAPL would continue to contribute to the aqueous plume of NAPL constituents.

In addition to the difficulty of locating NAPL and treating the large volume of soil containing residual or free-phase NAPL, the nature of the NAPL limits its potential for biodegradation. DNAPL at the site is composed primarily of PAHs, which have low volatility and sorb strongly to soil particles. As a result, it will be technically impracticable to completely remediate the DNAPL. However, an alternative remedial strategy will be implemented to protect human health and the environment.

2.5.2 ARARs Considered Technically Impracticable to Achieve

Owing to the site-specific factors described in the preceding section, the following ARARs cannot be achieved in a reasonable timeframe for specific constituents listed in Table 2-4:

- Safe Drinking Water Act: Primary Drinking Water Standards, MCLs and MCL Goals (MCLGs)
- Safe Drinking Water Act: Secondary Drinking Water Standards, Secondary MCLs
- New Jersey Groundwater Quality Standards (NJAC 7:9-6)
- New Jersey Drinking Water Standards: MCLs (NJAC 7:10)
- New Jersey Secondary Drinking Water Standards: Secondary MCLs (NJAC 7:10-7)

2.5.3 Spatial Area for Which It Is Technically Impracticable to Achieve ARARs

As stated in EPA's (1993) TI guidance document, the three areas that should be delineated at a NAPL site include the entry location, NAPL zone (area with free-phase or residual NAPL), and the aqueous plume. The NAPL zone and aqueous plume areas have been identified at the site and are depicted in Figure 1-5 as the lateral extent of NAPL and the composite extent of OU1, respectively. The NAPL entry location is presumed to be the location of historical site-related operations, which were present on the majority of the Quanta and

Block 93 North properties. The TI zone (composite extent of OU1) for which it is considered technically impracticable to achieve the above listed ARARs is depicted in Figure 2-2.

It is expected that there will be areas outside the TI zone that do not achieve groundwater ARARs for non-site related reasons. These reasons might include impacts from other unrelated sites, impacts from historical fill throughout the region, elevated regional background concentrations in groundwater or other similar considerations.

2.5.4 Alternative Remediation Strategy

Even the most aggressive remediation, such as extensive removal and hydraulic containment, would not achieve groundwater restoration. Serious consideration has been given to the applicability of innovative, emerging, and sustainable technologies in meeting EPA goals and expectations. An alternative remediation strategy for the site will be designed to prevent further migration of the plume, prevent human exposure to the contaminated groundwater, and evaluate further risk reduction measures.

Current and Future Exposure Pathways

Unacceptable future risks due to COCs in groundwater, as documented in the BHHRA for OU1, included exposure of construction workers to shallow groundwater and exposure of child and adult residents to both the unconfined groundwater zone (shallower than 10 feet bgs) and to the confined (deep sand) groundwater zone. These exposure pathways are discussed below.

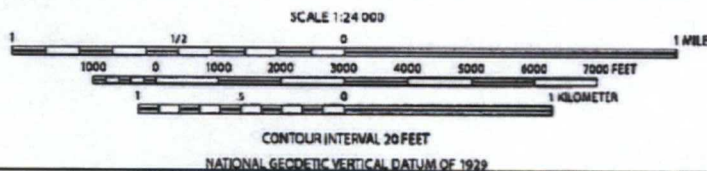
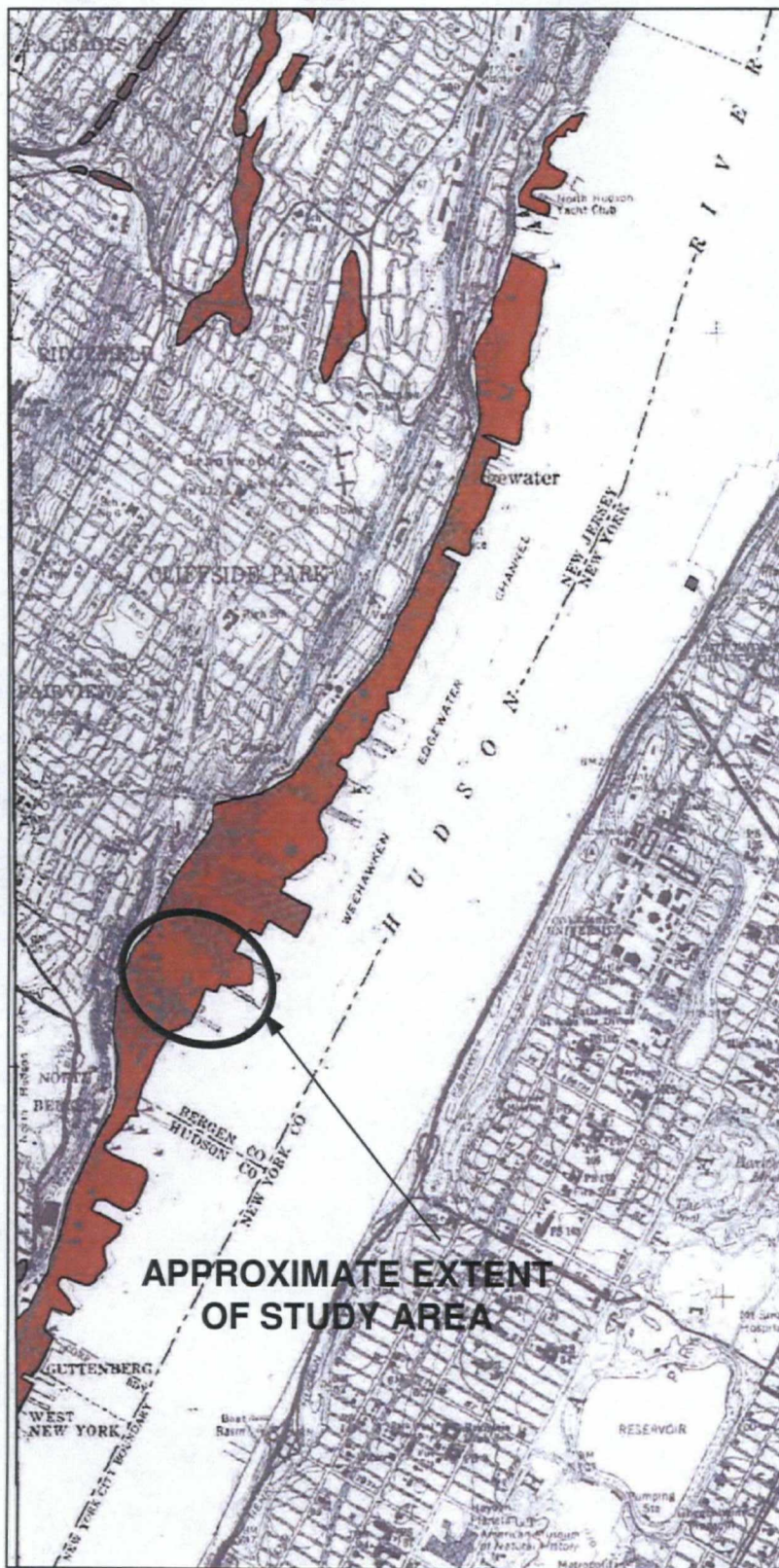
Future Construction Worker. Unacceptable future risks to the construction worker were calculated for exposure to the combination of shallow soil and shallow groundwater at the Quanta, former Celotex, 115 River Road, former Lever Brothers, and Block 93 North properties. An HHRA for the Block 93 Central and Block 93 South properties will be completed following the availability of validated data from the ongoing SRI in these areas. For the purposes of this FS, it is assumed that exposure to shallow groundwater on the Block 93 Central and South properties would pose unacceptable risk to the future construction worker. Therefore, at all properties, risk to this receptor must be mitigated via the alternate remediation strategy.

Residential Potable Water Source. Exposure to groundwater as a drinking water source is not a complete pathway. The pathway is expected to remain incomplete for the reasonably foreseeable future because groundwater at the site will not be used for potable purposes within a reasonable planning horizon (i.e., 30 years). There are no potable wells in the vicinity of the property, water supply planning for the area of the site does not identify any groundwater supply needs from the vicinity of the site, and water yield and natural quality of site groundwater are unlikely to meet potable water use requirements. Moreover, a reliable municipal water supply is readily available.

Urban Contaminants. In addition, the site is near busy roadways, where road salt applications occur during the winter, and near ongoing industrial and commercial activities, and PAHs from vehicle use may enter the groundwater system. The constant introduction of urban contaminants to the groundwater contributes to the degradation of regional groundwater quality, rendering it unsuitable for development of a potable water supply.

HISTORIC FILL OF THE CENTRAL PARK QUADRANGLE

2004



EXPLANATION

The "Brownfield and Contaminated Site Remediation Act" (N.J.S.A. 58:10B-1 et seq.) requires the Department of Environmental Protection to map regions of the state where large areas of historic fill exist and make this information available to the public. This map shows areas of historic fill covering more than approximately 5 acres. For the purposes of this map, historic fill is non-indigenous material placed on a site in order to raise the topographic elevation of the site. No representation is made as to the composition of the fill or presence of contamination in the fill. Some areas mapped as fill may contain chemical-production waste or ore-processing waste that exclude them from the legislative definition of historic fill.

Fill was mapped from stereo aerial photography taken in March 1979, supplemented in places by planimetric aerial photography taken in the spring of 1991 and 1992. Additional areas of fill were mapped by comparing areas of swamp, marsh, and floodplain shown on archival topographic and geologic maps on file at the N. J. Geological Survey, dated between 1840 and 1910, to their modern extent, in a few places, fill was mapped from field observations and from drillers' logs of wells and borings.

Most urban and suburban areas are underlain by a discontinuous layer of excavated indigenous soil mixed with varying amounts of non-indigenous material. This material generally does not meet the definition of historic fill and is not depicted on this map. Also, there may be historic fills that are not detectable on aerial photography or by archival map interpretation and so are not shown on this map, particularly along streams in urban and suburban areas.

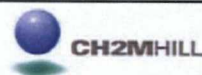
Use of the maps related to the Technical Rules, N.J.A.C. 7:26E

This map is provided for informational purposes only. The use of this map as the only source of information regarding the presence of historic fill at a site does not fulfill the diligent inquiry requirements of the Preliminary Assessment set forth at N.J.A.C. 7:26E-3.1(c). This map may be used as one source of information to fulfill the requirements of the Site Investigation at N.J.A.C. 7:26E-3.12. This map is not intended to fulfill the Remedial Investigation requirements associated with historic fill at N.J.A.C. 7:26E-4.8(b).

Historic Fill
Non-Fill Area



Map Source: NJDEP Land Use Management and New Jersey Geological Survey, Historic Fill of The Central Park Quadrangle, Historic Filling Map (HFM-43)

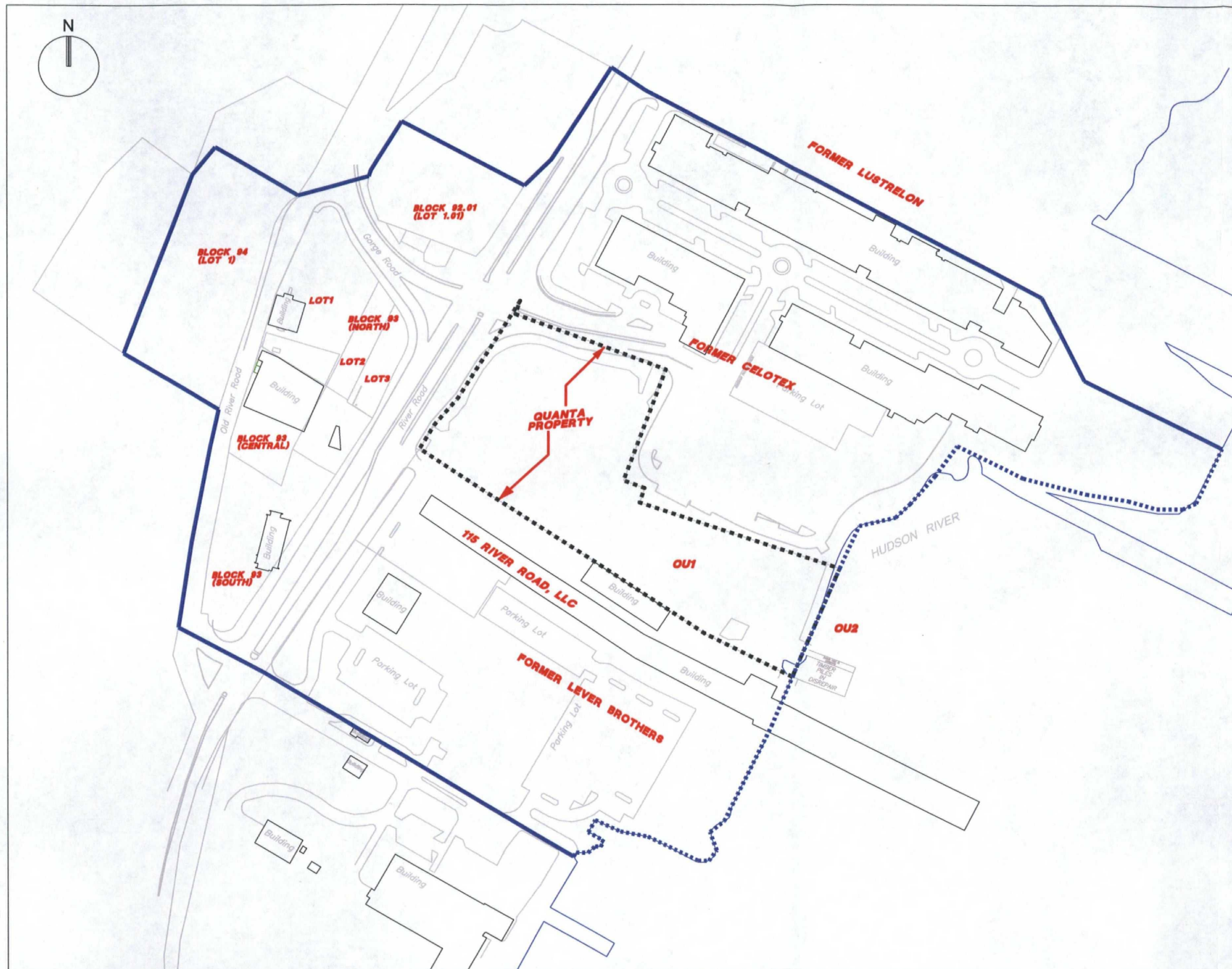


NJDEP Historic Filling Map

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

October 23, 2007

FIGURE 2-1

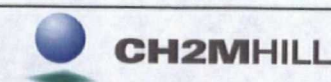
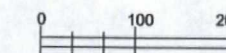


LEGEND

- QUANTA PROPERTY BOUNDARY
- PROPOSED EXTENT OF OU1 TI WAIVER FOR GROUNDWATER (WHERE DASHED - SEE NOTE #1 BELOW)

Notes:

- 1.) The extent of the area to be included as part of the Technical Impracticability (TI) Waiver for groundwater is dashed along the boundary of the Hudson River. The OU1/OU2 boundary will be assessed as part of the SRI. The TI Waiver for groundwater will extend to the groundwater-surface water interface at Operable Unit 2.
- 2.) Approximate property boundaries taken from most recent Bergen County Tax Maps.
- 3.) For purposes of this figure property lines are not extended into the Hudson River.



TECHNICAL IMPRACTICABILITY WAIVER BOUNDARY

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

September 16, 2008

FIGURE 2-2

TABLE 2-4
Technically Impracticable Chemical-Specific ARARs
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Parameter	Maximum Detected Concentration	Higher of NJ Class IIA and PQL	NJ Interim Generic	2004 Region 9 Tap Water PRG	NJ Primary Drinking Water Standard	NJ Primary and Secondary Drinking Water Standard	National Primary Drinking Water Standard	National Primary and Secondary Drinking Water Standard	Anomaly?	Non-Site Related?	Note	Exceedance and Detection Quantities
1,1'-Biphenyl	1,100	400	NA	300	NA	NA	NA	NA	—	—	—	Detected at 35 locations, exceeded in one sample at MW-116B.
1,1-Dichloroethane	120	50	NA	810	50	50	NA	NA	—	Yes	1	Detected at 9 locations, exceeded at MW-B only.
1,1-Dichloroethene	4	1	NA	340	2	2	7	7	—	Yes	1	Detected at 5 locations, exceeded at MW-101DS and MW-103DS.
1,2,4-Trichlorobenzene	13	9	NA	7.2	9	9	70	70	—	Yes	1	Detected at 4 locations, exceeded in one sample at MW-103A.
1,2-Dichloroethane	2.9	2	NA	0.12	2	2	5	5	—	Yes	1	Detected/exceeded at 3 locations: MW-101DS, MW-B, MW-103DS.
1,2-Dichloropropane	0.3	1	NA	0.16	5	5	5	5	—	Yes	1	Detected/exceeded at 1 location: MW-B.
1,4-Dichlorobenzene	2.5	75	NA	0.5	75	75	75	75	—	Yes	1	Detected/exceeded at 2 locations: MW-J, MW-113B.
2,4-Dimethylphenol	7,400	100	NA	730	NA	NA	NA	NA	—	—	—	Detected at 31 locations, exceeded at 16.
2-Methylnaphthalene	8,400	NA	100	NA	NA	NA	NA	NA	—	—	—	Detected at 39 locations, exceeded at 18.
2-Methylphenol	4,200	NA	100	1,800	NA	NA	NA	NA	—	—	—	Detected at 27 locations, exceeded at 9.
3&4-Methylphenol	68.6	NA	5	NA	NA	NA	NA	NA	—	—	—	Detected at 10 locations, exceeded at 7.
4,4'-Dichlorodiphenyldichloroethane	0.17	0.1	NA	0.28	NA	NA	NA	NA	—	Yes	2	Detected at 5 locations, exceeded at MW-103 (one sample).
4,4'-Dichlorodiphenyldichlorethylene	0.13	0.1	NA	0.2	NA	NA	NA	NA	—	Yes	2	Detected at 8 locations, exceeded at MW-103 (one sample).
4-Methylphenol*	5,800	NA	100	180	NA	NA	NA	NA	—	—	—	Detected at 26 locations, exceeded at 9.
Acenaphthene	3,300	400	NA	370	NA	NA	NA	NA	—	—	—	Detected at 49 locations, exceeded at 4.
Acenaphthylene	550	NA	100	NA	NA	NA	NA	NA	—	—	—	Detected at 33 locations, exceeded at 5.
Aldrin	0.032	0.04	NA	0.004	NA	NA	NA	NA	—	Yes	2	Detected/exceeded at 1 location: MW-117B.
Alpha-BHC	0.048	0.02	NA	0.011	NA	NA	NA	NA	—	Yes	2	Detected/exceeded at 2 locations: MW-112B, MW-117B.
Ammonia	24,100	3,000	NA	NA	NA	NA	NA	NA	—	—	—	Detected at 18 locations, exceeded at 13.
Aroclor-1260	6.1	0.5	NA	0.96	0.5	0.5	0.5	0.5	—	Yes	3	Detected/exceeded at 1 location: MW-J.
Arsenic	1,590,000	3	NA	0.045	5	5	10	10	—	—	4	Detected/exceeded at 68 locations.
Arsenic (III)	1,830,000	3	NA	0.045	NA	NA	NA	NA	—	—	4	Detected/exceeded at 13 locations.
Arsenic (V)	9,500	3	NA	0.045	NA	NA	NA	NA	—	—	4	Detected/exceeded at 5 locations.
Benzene	11,000	1	NA	0.35	1	1	5	5	—	—	—	Detected at 47 locations, exceeded at 41.
Benzo(a)anthracene	1,100	0.1	NA	0.092	NA	NA	NA	NA	—	—	—	Detected/exceeded at 32 locations.

TABLE 2-4
Technically Impracticable Chemical-Specific ARARs
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Parameter	Maximum Detected Concentration	Higher of NJ Class IIA and PQL	NJ Interim Generic	2004 Region 9 Tap Water PRG	NJ Primary Drinking Water Standard	NJ Primary and Secondary Drinking Water Standard	National Primary Drinking Water Standard	National Primary and Secondary Drinking Water Standard	Anomaly?	Non-Site Related?	Note	Exceedance and Detection Quantities
Benzo(a)pyrene	800	0.1	NA	0.0092	0.2	0.2	0.2	0.2	—	—	—	Detected/exceeded at 14 locations.
Benzo(b)fluoranthene	920	0.2	NA	0.092	NA	NA	NA	NA	—	—	—	Detected/exceeded at 17 locations.
Benzo(g,h,i)perylene	420	NA	100	NA	NA	NA	NA	NA	—	—	—	Detected at 8 locations, exceeded at 2.
Benzo(k)fluoranthene	450	0.5	NA	0.92	NA	NA	NA	NA	—	—	—	Detected at 7 locations, exceeded at 6.
Bis(2-ethylhexyl)phthalate	43	3	NA	4.8	6	6	6	6	Yes	—	—	Detected at 5 locations, exceeded at 1.
Caprolactam	140	NA	100	18,000	NA	NA	NA	NA	—	—	—	Detected at 15 locations, exceeded at 1.
Carbazole*	790	NA	5	3.4	NA	NA	NA	NA	—	—	—	Detected at 42 locations, exceeded at 39.
Chloroethane	8	NA	100	4.6	NA	NA	NA	NA	—	Yes	1	Detected at 9 locations, exceeded at 2: MW-B, MW-106A.
Chloroform	1.7	70	NA	0.17	NA	NA	NA	NA	—	Yes	1	Detected at 6 locations, exceeded at 5: MW-101DS, MW-B, MW-113C, MW-115B, MW-103DS.
Chrysene	1,000	5	NA	9.2	NA	NA	NA	NA	—	—	—	Detected at 24 locations, exceeded at 4.
Dibenzo(a,h)anthracene	41	0.3	NA	0.0092	NA	NA	NA	NA	—	—	—	Detected/exceeded at 6 locations.
Dibenzofuran*	2,200	NA	100	12	NA	NA	NA	NA	—	—	—	Detected at 43 locations, exceeded at 28.
Ethylbenzene	170	700	NA	1,300	700	700	700	700	—	—	—	Detected at 42 locations, exceeded at 11.
Fluoranthene	3,400	300	NA	1,500	NA	NA	NA	NA	—	—	—	Detected at 50 locations, exceeded at 2.
Fluorene	2,800	300	NA	240	NA	NA	NA	NA	—	—	—	Detected at 46 locations, exceeded at 3.
Heptachlor	0.016	0.05	NA	0.015	—	—	—	—	—	Yes	2	Detected at 3 locations, exceeded at 1: MW-117B.
Indeno(1,2,3-CD)pyrene	390	0.2	NA	0.092	NA	NA	NA	NA	—	—	—	Detected/exceeded at 8 locations.
Iron	401,000	300	NA	11,000	NA	300	NA	300	—	Yes	4	Detected/exceeded at 13 locations.
Lead	4,100	5	NA	NA	15	15	15	15	—	Yes	4	Detected at 51 locations, exceeded at 17.
Methylcyclohexane	1,300	NA	100	5200	NA	NA	NA	NA	Yes	—	—	Detected at 13 locations, exceeded at 1: MW-106A.
Naphthalene	36,000	300	NA	6.2	300	300	NA	NA	—	—	—	Detected at 51 locations, exceeded at 38.
Nitrobenzene	8	6	NA	3.4	NA	NA	NA	NA	Yes	—	—	Detected/exceeded at 1 location: MW-120A.
O-xylene	704	1,000	NA	210	NA	NA	NA	NA	—	—	—	Detected at 20 locations, exceeded at 3.
Phenanthrene	8,300	NA	100	NA	NA	NA	NA	NA	—	—	—	Detected at 48 locations, exceeded at 13.
Phenol	3,100	2,000	NA	11000	NA	NA	NA	NA	Yes	—	—	Detected at 20 locations, exceeded at 2: MW-102, MW-102A.
Pyrene	2,800	200	NA	180	NA	NA	NA	NA	—	—	—	Detected at 48 locations, exceeded at 3.

TABLE 2-4
Technically Impracticable Chemical-Specific ARARs
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Parameter	Maximum Detected Concentration	Higher of NJ Class IIA and PQL	NJ Interim Generic	2004 Region 9 Tap Water PRG	NJ Primary Drinking Water Standard	NJ Primary and Secondary Drinking Water Standard	National Primary Drinking Water Standard	National Primary and Secondary Drinking Water Standard	Anomaly?	Non-Site Related?	Note	Exceedance and Detection Quantities
Styrene	610	100	NA	1600	100	100	100	100	—	—	—	Detected at 4 locations, exceeded at 3: MW-121B, MW-102A, MW-103.
Tetrachloroethene	9.6	1	NA	0.1	1	1	5	5	—	Yes	1	Detected at 4 locations, exceeded at 3: MW-101DS, MW-B, MW-103DS.
Toluene	4,800	600	NA	720	1,000	1,000	1,000	1,000	—	—	—	Detected at 41 locations, exceeded at 11.
Trichloroethene	460	1	NA	0.028	1	1	5	5	—	Yes	1	Detected/exceeded at 10 locations: MW-101A, MW-101DS, MW-B, MW-107DS, MW-113B, MW-113C, MW-116DS, MW-122A, MW-29, MW-103DS.
Vinyl Chloride	4.4	1	NA	0.02	2	2	2	2	—	Yes	1	Detected/exceeded at 3 locations: MW-101DS, MW-B, MW-29.
Xylenes, M & P	1,210	1,000	NA	210	NA	NA	NA	NA	—	—	—	Detected at 21 locations, exceeded at 4.
Xylenes, Total	3,900	1,000	NA	210	1,000	1,000	1,000	1,000	—	—	—	Detected at 44 locations, exceeded at 19.

Notes:
All concentrations are presented in micrograms per liter (µg/L).
Shading indicates at least one sample collected during the OU1 RI exceeded the standard.
1 - Although chlorinated VOCs were detected in the deep sand groundwater, the source of these chlorinated VOC impacts is not the result of a release or releases related to Site-specific historical operations. Sporadic lower-level detections were observed in groundwater within the footprint of the Site-related impacts, as well as in offsite areas.
2 - Groundwater sampling results indicate that low concentrations of pesticides were detected within the interior portions of the Quanta property. These concentrations represent isolated, noncontiguous groundwater concentrations that are the result of the historical use of pesticides.
3 - Aroclor-1260 was detected at one location in the central portion of the Celotex property (MW-J). Polychlorinated biphenyls (PCBs) adsorb strongly to soils and have not been detected in groundwater ; this observed concentration is not considered related to Site operations.
4 - Constituent has been identified as both a site-related constituent and a component of historical fill material.
PRG - Preliminary Remedial Goal
ARARs - Applicable or relevant and appropriate requirements
VOC - Volatile Organic Constituents
PQL - Practical Quantitation Limit
OU1 - Operable Unit 1
RI - Remedial Investigation

Specifically, NJDEP (2004b) drinking water criteria may be exceeded for chloride (250 mg/L), sodium (50 mg/L), and total dissolved solids (500 mg/L), among other parameters outlined in the NJDEP guidance. Select wells along the periphery of the site are being sampled as part of the SRI. The suitability of groundwater for use as drinking water relative to these non-site-related constituents will be evaluated once these data are available.

Saltwater Intrusion. Surface water (the Hudson River) near the site has been documented as saline and therefore may result in saltwater intrusion should groundwater at the site be pumped as a potable water supply (NJDEP, 2003). The U.S. Geological Survey defines the saltwater–fresh water interface as the farthest daily upstream location that has a chloride concentration of 100 mg/L and depicts this front as being approximately 5 miles south of West Point, New York (Hoffman, 2008). This location is approximately 40 miles upstream of the site. Salt water in the Hudson River has also been documented to extend to the first 100 km of the river during low flow and 30 km during freshet periods, or times of sudden flooding, such as rapid thaw or heavy rainfall periods (Traykovski et al., 2004). Based on the NJDEP guidance document on water supply wells (NJDEP, 2007) saltwater intrusion from the river would preclude the use of groundwater from the site as a potable water supply.

Hydrogeologic Conditions. In addition to the poor quality of the groundwater that precludes its use as potable water, NJDEP water supply well construction regulations prohibit using the shallow aquifer as a water supply. NJDEP requires that potable water supply wells installed within unconsolidated formations have well casings that are at least 50 feet deep, with at least 50 feet of grout seal extending from the top of the gravel pack or top of the well screen to grade (NJDEP, 2007). Because the overburden at the site is confined to depths shallower than this, this requirement cannot be met (CH2M HILL, 2008a).

Alternative Remediation Goals

Alternate remediation goals to protect reasonably foreseeable uses/exposure to groundwater must be selected in lieu of waived ARARs. As clarified in the preamble to the proposed Subpart S to 40 CFR 264 and stated by EPA (1993), "...alternative levels protective of the environment and safe for other uses could be established for ground water that is not an actual or reasonably expected source of drinking water" (p. 1).

As discussed in the previous subsection, the only reasonable exposure scenario for groundwater at OU1 is exposure of future construction workers to shallow groundwater (less than 10 feet bgs). The proposed alternate remedial strategy consists of four components:

- Remove or treat principal threat waste within the TI zone where practicable and where significant reduction of current or future potential risk would result
- Contain or treat low-level threat waste within the TI zone, when feasible, and when a significant reduction in dissolved concentration would result
- Prevent exposure of the future construction worker to COCs in shallow groundwater within the TI zone
- Prevent site-related COCs from migrating outside the TI zone at concentrations above ARARs

As discussed in detail in the RI and in Section 1.8.3 of this FS, the fate and transport assessment of groundwater constituent migration indicate that the plume of dissolved constituents in groundwater is stable. Mechanisms that control migration include advective flow, geochemical conditions, and constituent-specific attenuation factors. These mechanisms are preventing the further migration of dissolved-phase VOCs, PAHs, non-PAH SVOCs, and arsenic in groundwater. The data collected to date provide multiple lines of evidence to support the conclusion that natural processes are sufficient to contain and prevent further expansion of the extent of dissolved phase constituents in groundwater. Data collection activities are ongoing at the site as part of the SRI to provide a better understanding of these specific processes and confirm that they are continuing to be effective in preventing further expansion of groundwater plumes.

There are, however, areas at the site where secondary sources of NAPL are contributing to dissolved naphthalene and other PAHs near the Hudson River. Given the understanding of advective groundwater flow and the migration potential of naphthalene in groundwater, dissolved-phase naphthalene, and to a lesser extent other less mobile PAHs may be migrating in groundwater from OU1 toward the Hudson River. The remedial strategy will therefore focus specifically on preventing COCs in OU1 groundwater from migrating into OU2.

Additional data collection has been proposed as part of the SRI to supplement the existing data set and demonstrate that concentrations and plume geometry are stable over time. These results will be presented in the SRI report for OU1.

Identification and Screening of Technologies

3.1 General Response Actions

General response actions are actions that might be undertaken to satisfy the RAOs for a site. After the RAOs and PRGs were developed, general response actions consistent with these objectives were identified for each media type at OU1. As part of the OU1 FS alternatives analysis process, general response actions have been further divided into a series of specific technologies and process options as described in Section 3.2. These technologies have then been screened for applicability and potential effectiveness. The following sections present the general response actions that may be applicable to each media type at the site and detail the subsequent technology-screening process. The technologies and process options remaining after screening have been assembled into alternatives for OU1 which are presented and discussed in detail in Section 4.

3.1.1 General Response Actions for Free-Phase NAPL

The general response actions for free-phase NAPL at OU1 include the following:

- No further action (NFA)
- Institutional controls
- Containment
- In situ treatment
- Removal/disposal

An overview of some of the technologies that are representative of each general response action is provided below.

No Further Action

An NFA response would assume no remedial action for free-phase NAPL beyond what may have been implemented in the past. NFA would not satisfy the RAO for preventing offsite migration and human exposure to source material; therefore, this action is not feasible. The NCP requires that the NFA alternative be retained through the FS process as a basis of comparison.

Institutional Controls

Institutional controls consist of restricting access to source material through options such as land use restrictions (i.e., deed notices). Institutional controls considered would be prepared in accordance with NJDEP requirements for deed notices and biennial monitoring (NJAC 7:26E-8.4 through 8-6). Deed notices are the NJDEP presumptive remedy for sites with contaminated historic fill material (NJAC 7:26E-6.2(c)). Use of institutional controls alone would not achieve the RAOs for source material; therefore, these measures would have to be used in conjunction with other technologies.

Containment

Containment technologies may be used to reduce the potential for offsite migration of NAPL. For example, interlocking steel piles may be driven into the subsurface along the boundaries of the NAPL zones, or trenches around the NAPL zones may be excavated and filled with slurry of low-permeability material to provide a barrier. Permeable reactive barriers (PRBs) may be constructed using a material that allows the flow of groundwater while restricting the flow of NAPL.

In Situ Treatment

In situ treatment of NAPL involves treating it without removing it from the subsurface. Such treatment may be achieved by applying physical, chemical, biological, or thermal technologies. Examples of possible approaches to in situ treatment of NAPL include chemical oxidation or solidification/stabilization technologies.

Removal/Disposal

NAPL may be collected for offsite disposal using interception trenches or recovery wells. Recovered NAPL may require processing prior to being disposed of offsite.

3.1.2 General Response Actions for Soil

The general response actions for soil at OU1 include the following:

- NFA
- Engineering and Institutional controls
- Containment
- In situ treatment
- Removal/disposal

An overview of some of the technologies that are representative generally of each response action is provided below.

No Further Action

The NFA action response assumes no remedial action for soil beyond what may have been implemented in the past. An NFA response for low-level threat waste would not satisfy the RAO of preventing potential future unacceptable human health risk; therefore, this action is not feasible. The NCP requires that the NFA alternative be retained through the FS process as a basis of comparison.

Engineering and Institutional Controls

Institutional controls for soil consist of restricting access to contaminated soil through options such as land use restrictions (i.e., deed notices). Institutional controls considered would be prepared in accordance with NJDEP requirements for deed notices and biennial monitoring (NJAC 7:26E-8.4 through 8-6). Deed notices are the NJDEP presumptive remedy for sites with contaminated historic fill material (NJAC 7:26E-6.2(c)). Use of institutional controls alone would not achieve the RAOs for low level threat waste; therefore, these measures would have to be used in conjunction with other technologies.

Containment

Containment response actions, such as caps, are used to prevent direct contact exposures or migration of constituents following dissolution or volatilization. Asphalt, soil caps, concrete caps, and liner materials are applicable remedial technologies that can be used to restrict exposure to contaminated soil. These actions will also minimize the infiltration of precipitation and help prevent migration of constituents offsite. Surface controls such as grading and revegetation can also be used to reduce infiltration of precipitation through contaminated soil and prevent erosion and transport of contaminated soil.

In Situ Treatment

In situ treatment includes remedial actions that do not require removing contaminated media. Applicable in situ remedial technologies that can be used include physical/chemical, biological, and thermal processes. Some examples of in situ treatment that may be applicable at sites with metals contamination in soil include solidification/stabilization, soil flushing, and phytoremediation. A variety of in situ methods is available for treating organic contaminants in soil, including soil vapor extraction (SVE), ISCO below the water table, thermal desorption, and physical/chemical stabilization to reduce leachability.

Removal/Disposal

Excavation and removal of soil would prevent direct contact, ingestion, or inhalation of contaminated soil. This general response action would also mitigate the potential migration of constituents via windblown erosion or surface water runoff from excavated areas. Excavation of material above the water table may be performed relatively cost-effectively as a means of achieving RAOs. Excavation can be performed to depths of approximately 4 feet without groundwater dewatering and treatment and up to 20 feet using readily available equipment. Deeper excavation and excavation below the water table is possible with more-specialized equipment and would result in significant increases in worker health and safety measures as well as costs. The excavated soil may be disposed of onsite or offsite, depending on state and federal requirements. Excavation and offsite disposal provides assurance that contaminant mass is removed from target cleanup areas. Offsite disposal would significantly affect the community through increased traffic and vehicular emissions.

Treatment of excavated soils may be required to reduce leachability or contaminant concentrations prior to disposal. Excavating soil prior to performing treatment can increase treatment effectiveness by homogenizing the soil and increasing its permeability. Soil fixation or stabilization can be used to immobilize contaminants by physically binding them, enclosing them within a stable mass, or chemically treating them to reduce leaching. Ex situ thermal treatment can also be performed on excavated soil. Ex situ biological treatment is typically not used to treat high concentrations of PAHs because of poor contaminant degradation, resulting in long treatment times and reduced treatment effectiveness. The presence of arsenic and other co-contaminants may also inhibit biological activity.

Several hazardous waste landfills in North America receive, stabilize, and dispose of characteristically hazardous soil. These facilities would likely accept the tar- and arsenic-contaminated soil from the site for treatment prior to disposal. Analysis of prequalification samples is performed to determine whether the waste is acceptable for onsite processing

and disposal. This analysis is done to determine whether the material can be processed and disposed of in the landfill.

3.1.3 General Response Actions for Groundwater

The general response actions applicable to groundwater containing dissolved COCs above PRGs are the following:

- NFA
- Institutional controls
- Containment
- MNA
- In situ treatment
- Collection, treatment, and discharge

An overview of some of the technologies that are representative of each general response action is provided below.

No Further Action

The NFA response is no further action for groundwater. As with the NFA alternative for soil, this alternative is retained through the FS process as a basis of comparison, in accordance with the NCP. The NFA response for groundwater will be coupled with the NFA option for soils as a basis of comparison.

Institutional Controls

Institutional controls for groundwater include restrictive covenants that limit the potential future use of affected groundwater. In New Jersey, NJDEP may designate a Classification Exception Area (CEA) to designate areas of exception to strict application of New Jersey Ground Water Quality Standards in certain, specific situations. Continued groundwater monitoring may also be necessary to track the groundwater contaminant plume as part of the institutional controls.

Other institutional controls may be applied through the use of local ordinances such as easements, well-drilling prohibitions, building permit restrictions, land use zoning restrictions, fishing bans, and the use of state registries of contaminated sites. Such institutional controls would typically specify the nature and extent of the groundwater constituents and prohibit its use until the groundwater constituents returns to drinking water standards. Use of institutional controls alone would not achieve the RAOs for groundwater; therefore, these measures would have to be used in conjunction with other technologies.

Containment

Containment of groundwater refers to controlling migration of dissolved phase constituents through the use of barriers or hydraulic gradient control. Examples of groundwater containment include using slurry or sheet-pile walls or pumping groundwater. Installation of a hydraulic barrier perpendicular to groundwater flow will likely result in mounding on the upgradient side of the barrier and may require groundwater extraction to control flow around the barrier. Hydraulic barriers can also be used in a funnel-and-gate configuration:

A contaminant plume is channeled between impervious vertical walls, referred to as the funnel, and flows naturally through a PRB gate, where the pollutants are treated in situ during the flow process.

Monitored Natural Attenuation

Natural attenuation is the reduction of constituent concentrations through natural physical, chemical, or biological processes. These processes may include biodegradation, dilution, dispersion, and retardation. When natural attenuation is implemented as a remedy, monitoring is typically required to document the decrease in constituent concentrations.

In Situ Treatment

In situ treatment of groundwater entails treating the groundwater in the aquifer, which can be achieved by applying physical/chemical, biological, or thermal techniques. Examples of possible approaches to in situ treatment include chemical oxidation, PRBs, air sparging, and biological treatment technologies.

Collection, Treatment, and Discharge

In this response action, groundwater is collected using extraction wells or interception trenches, treated using physical, chemical, or biological treatment methods to remove the constituents, and then discharged. The treated groundwater can be discharged by surface infiltration, by subsurface injection, to surface water, or to a publicly owned treatment works (POTW). The collection, treatment, and discharge response action can also control migration of impacted groundwater.

3.2 Technology Screening

3.2.1 Methodology

The technology types and process options available for remediation of NAPL, soil, and groundwater have been screened, as presented below. Screening of technology methods begins with development of an inventory of technology types and process options based on professional experience, published sources, computer databases, and other available documentation for the general response actions identified in Section 3.1.

Each technology type and process option retained after the screening process is either a demonstrated, proven process or a potential process that has undergone laboratory trials or bench-scale testing. The initial screening of technology types and process options is based on technical implementability. The following factors are included in this evaluation:

- State of technology development
- Site conditions
- Waste characteristics
- Nature and extent of contamination
- Presence of constituents that could reduce the effectiveness of the technology

Entire technologies or individual process options may be screened from further consideration on the basis of technical implementability.

Process options that remain after the initial screening are further evaluated using a qualitative comparison based on the criteria of potential effectiveness, implementability, and cost. The effectiveness of a process option is determined based on the ability of the process option to perform as part of a comprehensive remedial plan to meet RAOs under the conditions and limitations present at the site. The NCP defines effectiveness as the “degree to which an alternative reduces toxicity, mobility, or volume through treatment, minimizes residual potential risk, affords long-term protection, complies with ARARs, minimizes short-term impacts, and how quickly it achieves protection.”

Effectiveness is a relative measure that is used to compare process options that perform the same or similar functions. “Implementability” refers to the relative degree of difficulty anticipated in implementing a particular process option under regulatory, technical, and schedule constraints posed at the site. At this point, the cost criterion is used for comparative purposes only. Similarly, implementability is used to preclude further evaluation of process options that are very costly if there are other choices that perform similar functions with similar effectiveness. The cost criterion addresses costs of construction and long-term costs to operate and maintain technologies that are part of an alternative.

NAPL, soil, and groundwater remedial technologies were screened with the methodology described. The remedial technologies and process options that remained after the initial screening were further evaluated using the qualitative comparison based on effectiveness, implementability, and cost. The technologies evaluated are summarized in Tables 3-1, 3-2, and 3-3 for NAPL, soils, and groundwater, respectively. Technologies considered infeasible after screening are shown in italicized and bolded text. Screening comments are provided to highlight items of interest or concern for each option. This approach highlights differences within a remedial technology group to allow the best process within each group to be identified and selected. Following the qualitative screening, those remedial technology types and process options considered potentially viable for remediating the media at the site are carried forward for incorporation into alternatives.

3.2.2 Technology Screening for Free-Phase NAPL

Table 3-1 presents the screening of remedial technologies and process options for NAPL. The following technologies were retained for further consideration:

- **NFA:** Retained to meet requirements of the NCP. No remedial technologies are implemented with the option.
- **NAPL recovery trench:** Passive recovery trench technology allows for the separation of NAPL from groundwater for extraction and offsite disposal, thereby controlling migration.
- **NAPL recovery wells:** Active NAPL recovery wells allow for the extraction of free-phase NAPL from areas within the site. Extracted NAPL would be disposed of offsite but may require some treatment or handling prior to disposal.
- **Physical containment:** Physical containment of free-phase NAPL may be achieved through the installation of impermeable vertical barriers such as sheet piling or slurry

walls or through the installation of PRBs that allow groundwater flow but restrict NAPL.

- **In situ chemical oxidation:** ISCO involves injection of an oxidant such as sodium persulfate or Fenton's reagent into the target treatment zone to chemically oxidize organic constituents below the water table. The ensuing reaction then oxidizes the organic constituents it contacts. Multiple injections may be required to achieve remediation goals. ISCO may also be effective in changing the redox conditions so that some arsenic precipitates within the soil matrix. A bench-scale treatability test was conducted to determine the effectiveness of ISCO on NAPL, arsenic, and other site constituents and is described in Appendix B.
- **Stabilization/solidification:** Constituents are physically bound within a stabilized mass (solidification), or chemical reactions are induced to reduce constituents' mobility (stabilization). Stabilization/solidification has been proven to be effective to treat coal tar wastes and inorganics such as arsenic wastes.

3.2.3 Technology Screening for Soil Media

Table 3-2 presents the screening of remedial technologies and process options for soil media, including residual NAPL. The following technologies were retained for further consideration:

- **NFA:** Retained to meet requirements of the NCP. No remedial technologies are implemented with the option.
- **Institutional controls:** Institutional controls for soil consist of restricting access to contaminated soil through land use restrictions (such as deed notices under NJDEP requirements).
- **Soil cover:** Involves placing a soil cover over contaminated soils to control erosion and prevent direct contact exposure. A cover is distinguished from a cap in that the purpose of the cover is not to m infiltration. Surface controls such as grading and revegetation are typically used to reduce erosion and manage surface water.
- **Soil multilayer cap:** This technology involves placing a multilayer soil cap over contaminated soils along with using controls for managing surface drainage. This approach differs from a soil cover in that a synthetic liner material is used to minimize the infiltration of surface water. As with the soil cover technology, surface controls such as grading and revegetation are usually included to control drainage.
- **Stabilization/solidification:** Constituents in soil are physically bound within a stabilized mass (solidification), or chemical reactions are induced to reduce constituents' mobility (stabilization). Stabilization/solidification has been proven to be effective to treat coal tar wastes and inorganic material such as arsenic wastes.
- **In situ chemical oxidation:** ISCO involves injection of an oxidant such as sodium persulfate or Fenton's reagent into the target treatment zone to chemically oxidize organic constituents below the water table. The ensuing reaction then oxidizes the organic constituents it contacts. Multiple injections may be required to achieve remediation goals. ISCO may also be effective in changing the redox conditions so that

some arsenic precipitates within the soil matrix. A bench-scale treatability test was conducted to determine the effectiveness of ISCO on residual NAPL, arsenic, and other site constituents, and is described in Appendix B.

- **Excavation:** This technology involves physically removing contaminated soils, typically above the water table. Excavation of soils below the water table generally requires management of the water generated through the dewatering process and, in some cases, requires the need for sheet pile to manage the groundwater flow.
- **Ex situ stabilization:** This technology involves the addition of a solidification agent such as cement to reduce the leachability of the constituents. It would be used only if needed to meet land disposal restriction limits for soil prior to landfilling it.
- **Offsite disposal at Subtitle C or D landfill:** This technology involves disposing of removed material in a RCRA Subtitle C or D permitted landfill.

3.2.4 Technology Screening for Groundwater Media

Table 3-3 presents the screening of remedial technologies and process options for groundwater media. The following technologies were retained for further consideration:

- **NFA:** Retained to meet requirements of the NCP. No remedial technologies are implemented with the option.
- **Institutional controls:** Groundwater use restrictions in the form of a CEA, in accordance with the NJDEP regulations (NJAC 7:26E-8.4), are the applicable groundwater use restrictions for the site. The components of the CEA include the location of the restriction (which includes the potential migration locations before degradation reduces to below applicable cleanup criteria), the compounds detected over the applicable cleanup criteria within the restricted area, and the proposed duration of the restriction. This control would prohibit future use of the groundwater within this area and would restrict the installation of wells over the duration of the CEA.
- **MNA:** Natural attenuation is the reduction of constituent concentrations through natural physical, chemical, or biological processes. These processes may include biodegradation, dilution, dispersion, and retardation. When natural attenuation is implemented as a remedy, monitoring is typically required to document the decrease in constituent concentrations. Only unaugmented natural processes are considered under this technology.
- **In situ passive treatment barrier:** PRB technology provides for treating dissolved-phase constituents in shallow groundwater prior to its discharge offsite. Designs for this technology may consist of zero-valent iron or air sparging.
- **Subaqueous reactive barrier:** A subaqueous reactive barrier (SRB) is a mat consisting of a reactive material treats groundwater prior to its discharge to the river. The mat is installed in the river at the area of discharge and with a sand or armor layer to secure the mat in place.
- **In situ chemical oxidation:** ISCO involves injection of an oxidant such as sodium persulfate or Fenton's reagent into the target treatment zone to chemically oxidize

organic constituents below the water table. The ensuing reaction then oxidizes the organic constituents it contacts. Multiple injections may be required to achieve remediation goals. ISCO may also be effective in changing the redox conditions so that some arsenic precipitates within the soil matrix. A bench-scale treatability test was conducted to determine the effectiveness of ISCO on residual NAPL, arsenic, and other site constituents, and is described in Appendix B.

- **Groundwater extraction and treatment:** This technology involves extracting groundwater to create a hydraulic barrier to prevent further migration of constituents from the source area. Containment minimizes the spread of groundwater constituents through active hydraulic gradient controls, such as groundwater pumping. Groundwater is extracted from the shallow aquifer using pumping wells. The constituents are then treated ex situ (as discussed in the following paragraphs) for ultimate disposal, as required according to the requirements of the chosen discharge option. Initially, active pump-and-treat operations can be highly effective; however, this process option becomes much less effective with time. Pump-and-treat operations involve collecting larger volumes of groundwater than other alternatives involving groundwater extraction, such as using active hydraulic controls. Active hydraulic controls require the pumping of lower volumes of water, not for the purpose of collecting and treating contaminated water, but to prevent offsite migration of groundwater by capturing the downgradient edge of the plume as it naturally migrates through the area.
- **Groundwater discharge:** Several discharge options are available for treated groundwater, such as injection of treated groundwater back into the unconfined aquifer, discharge to the POTW, and discharge to surface water. After review of the hydrogeologic conditions at the site, and the discharge requirements necessary, reinjection was determined to not be appropriate for the site because of the high water table. Mounding concerns and nearby surface water also make this option undesirable. Discharge to the POTW may be an option but connection and discharge fees for the life of the remedial action might be required. Additional monitoring requirements—such as total solids, lower explosive limits, biological oxygen demand and chemical oxygen demand, and limitations of permits—may also dictate discharge to the POTW. The POTW, through an application-to-discharge process, would have to approve the acceptance of any discharge. Discharge to surface water must also meet specific discharge permit requirements.

TABLE 3-1
Technology/Process Options for Operable Unit 1 – Free-Phase NAPL
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/O&M Cost	Screening Comments
No Action	No Further Action	None	No action.	Technically implementable	None	Good	None/None	Required for comparison by National Contingency Plan (NCP); does not meet remedial action objectives (RAOs).
Institutional Controls	Deed Restrictions on Access and Use	None	Deed restrictions issued for property and/or source area to restrict future land use and control future construction and redevelopment activities.	Technically implementable	Good	Good	NA/Low	Retained for further evaluation.
	Monitoring		Short- and/or long-term monitoring is implemented to record site conditions and concentration levels.	Technically implementable	Good	Good	NA/Low	Retained for further evaluation.
Containment	Vertical Barriers	Sheet Pile	Interlocking steel piles are driven into the subsurface along the boundaries of the NAPL zones.	Limited by existing structures and large fill debris	Demonstrated	Fair	High/Medium	In-situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment barrier (see below) to create a funnel and gate directing groundwater flow through the treatment area.
		Slurry Wall	Trench around the NAPL zones is excavated and filled with a slurry of low permeability material to provide a barrier.	Limited by existing structures	Demonstrated	Fair	High/Medium	In-situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment barrier (see below) to create a funnel and gate directing groundwater flow through the treatment area.
In Situ Treatment	Chemical	In Situ Chemical Oxidation (ISCO)*	ISCO that employs various oxidants and delivery techniques to mineralize contaminants. Oxidants may include hydrogen peroxide, potassium and sodium permanganate, sodium persulfate, and ozone. Oxidant chemicals are injected directly into the source zone and downgradient plume. Multiple injections may be required to achieve remediation goals.	Technically implementable	Potential	Low	High/Medium	This technology may be capable of reducing the quantity of free-phase NAPL at the Site; however the quantity of reagent required to oxidize free-phase NAPL in-situ would likely be difficult to inject. Heat generated from the reaction would likely mobilize residual NAPL during and after implementation, and may result in significant generation of vapors.
		Surfactant-Enhanced ISCO	<i>S-ISCO technology uses the injection of a surfactant-cosolvent mixture to dissolve NAPL into an aqueous phase. This allows aqueous phase oxidant reactions to destroy solubilized NAPL. Multiple injections may be required to achieve remediation goals.</i>	<i>Technically implementable</i>	<i>Potential</i>	<i>Low</i>	<i>High/Medium</i>	<i>This technology may be capable of reducing the quantity of NAPL; however, there is very limited experience with this technology on coal tar sites full scale (one to date). In addition, the ability to recover the surfactant-cosolvent mixture would be a concern adjacent to the Hudson River and would be difficult due to the heterogeneity of the soils and unknown substructures.</i>
	In Situ Passive Treatment Barrier	Permeable Reactive Barrier (PRB)	PRB technology can be used to allow groundwater to flow through the barrier while NAPL migration is prevented.	Technically implementable	Potential	Fair	High/Medium	PRB technology may be applicable to mitigate the potential risk of NAPL migration without obstructing groundwater flow.
	Solidification/Stabilization (S/S)	Auger/caisson system	Constituents are physically bound within a stabilized mass (solidification), and/or chemical reactions are induced to reduce contaminants' mobility (stabilization). These systems are used to apply solidifying/stabilizing reagents to soils. Reagents and dosage used are the primary design considerations. Surface and subsurface objects, >12 inches in diameter, must be removed before treatment.	Technically implementable	Good	Good	Medium/NA	This technology is retained for inclusion in remedial alternatives for free-phase NAPL. Solidification/Stabilization can reduce the mobility of contaminants and provides a decreased exposed surface area across which contaminant loss may occur.

TABLE 3-1
Technology/Process Options for Operable Unit 1 – Free-Phase NAPL
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Ex Situ treatment	NAPL Extraction	Recovery Trenches	Trenches within areas of free-phase NAPL are installed and backfilled with low-permeability material such as pea gravel. NAPL preferentially flows into the low-permeability material and collects in sumps for extraction.	Technically implementable	Fair	Fair	Medium-High/Medium	This technology is retained for inclusion in remedial alternatives for free-phase NAPL. Installation of trenches may be infeasible below 25 feet bgs or in areas with subsurface obstructions.
		Recovery Wells	Large-diameter boreholes are installed with extraction wells and sumps. The boreholes are backfilled with low-permeability material such as pea gravel.	Technically implementable	Fair	Fair	Medium-High/Medium	This technology is retained for inclusion in remedial alternatives for free-phase NAPL. Recovery wells could be installed in areas with subsurface obstructions using air-rotary or other drilling methods.
		<i>Dual Phase Extracation (DPE)</i>	<i>DPE uses a high vacuum and groundwater pumping to induce flow of NAPL towards the DPE well. It also lowers the water table to expose the aquifer matrix to more rapid remediation via soil vapor extraction. The extracted liquid (i.e., NAPL and groundwater) and vapors are treated ex situ.</i>	<i>Technically implementable</i>	<i>Fair</i>	<i>Low</i>	<i>Medium/High</i>	<i>This technology is not retained due to difficulty in dewatering the relatively high permeable soil.</i>
Disposal	Asphalt Batching		This technology incorporates recovered NAPL into asphalt material for reuse in paving applications. The physical and chemical characteristics of the recovered NAPL may not be appropriate for asphalt batching.	Technically implementable	Potential	Fair	Low/NA	This disposal option is retained for potential use in NAPL remedial alternatives.
	Stabilization and Disposal		This technology involves offsite stabilization and disposal of recovered NAPL in accordance with land disposal requirements.	Technically implementable	Good	Fair	Medium/NA	This disposal option is retained for potential use in NAPL remedial alternatives.

Notes:

Italicized and bolded text indicates technology or process option was screened from further consideration.

* Innovative Application of Technology

ISCO – In Situ Chemical Oxidation

NAPL – Non-Aqueous Phase Liquid

NPL – National Contingency Plan

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TABLE 3-2
Technology/Process Options for Operable Unit 1 – Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/O&M Cost	Screening Comments
No Action	No Further Action	None	No action.					Required for comparison by National Contingency Plan (NCP); does not meet remedial action objectives (RAOs).
Engineering and Institutional Controls	Institutional Controls	Land Use Restrictions	Restrict access to contaminated soils through local ordinances, building permits, restrictive covenants on property deeds (Deed Notice) and state registries of contaminated sites.	Technically implementable	Fair – Must be combined with other technologies	Fair	Low/Low	Does not meet RAOs when implemented alone; may be applicable in conjunction with other technologies.
	Cap	Multi-layer	Capping the soil to prevent direct contact and to reduce infiltration is often combined with barrier wall technology, and could include clay, geotextile, asphalt, or multilayer caps with vegetative cover.	Technically implementable	Demonstrated	Good	High/low	Encapsulation does not reduce concentrations of constituents. Inspection and replacement requirements of either a barrier wall or a cap will limit future site use.
	Cover	Soil	Place clean fill over contaminated soils.	Technically implementable	Demonstrated	Good	Moderate/Low	A soil cover may be feasible to prevent direct contact with impacted soil.
Containment	<i>In-situ barrier wall</i>	<i>Poly-vinyl chloride-bentonite barrier wall</i>	<i>Encapsulation involves isolating impacted soil and groundwater with vertical barriers to cut off migration pathways between the contaminants and potential human and ecologic receptors.</i>	<i>Limited by existing structures</i>	<i>Demonstrated</i>	<i>Poor</i>	<i>High/low</i>	<i>Encapsulation does not reduce concentrations of constituents. Construction of a barrier wall encapsulating the entire area of NAPL or arsenic-impacted soil at Operable Unit 1 would be difficult due to the presence of the 115 River Road building and other existing surface features. This technology is not retained for soil but may be retained for groundwater containment (refer to Table 3-3).</i>
In-Situ Treatment	<i>In-Situ soil washing</i>		<i>In-situ soil washing involves the upgradient injection or infiltration of a cosolvent (such as an alcohol) to dissolve otherwise insoluble contaminants into groundwater for extraction, treatment, and disposal. Extracted groundwater with flushing fluids or cosolvents is often treated to recover and reuse the cosolvent. This technology would likely not work effectively on heavy PAH-impacted soils.</i>	<i>Technically implementable</i>	<i>Potential for arsenic, poor for residual NAPL</i>	<i>Fair</i>	<i>High/medium</i>	<i>Effectiveness may be limited in lower-permeability soils, and this technology has not been effective at non-aqueous phase liquid (NAPL) sites; however this technology could be effective in treating arsenic and other metal contamination. The presence of NAPL in the treatment area may limit the effectiveness of this technology. This technology was not retained because more cost-effective in-situ treatment technologies for metal contamination are available.</i>
	<i>In-situ vitrification</i>		<i>Vitrification involves heating soil to the melting temperature (approximately 2,000°C) and removing and recovering or destroying the volatilized contaminants. The remaining vitrification product is a chemically stable, leach-resistant, glass and crystalline material similar to obsidian or basalt rock, and can be left in place or broken up, excavated, and crushed for recycling or disposal. Water vapor and combustion products are captured and treated by an off-gas treatment system.</i>	<i>Potentially implementable</i>	<i>Potential</i>	<i>Poor</i>	<i>High/low</i>	<i>The high water table, the presence of NAPL in soils and the non-homogeneity of the fill material at the site renders this technology infeasible. Extensive dewatering would be required to treat areas below the water table, and when combined with very high energy demands, this technology becomes cost-prohibitive. More feasible and cost-effective technologies are available for source zone treatment.</i>

TABLE 3-2
Technology/Process Options for Operable Unit 1 – Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/O&M Cost	Screening Comments
In-Situ Treatment	<i>In-situ soil vapor extraction (SVE)</i>		<i>Volatilized contaminants migrate into the unsaturated zone where they can be extracted by an SVE system and treated or sequestered. SVE is typically effective for contaminants with low boiling points and high vapor pressures.</i>	<i>Potentially implementable – would need to be confirmed with pilot test</i>	<i>Poor for arsenic and PAHs</i>	<i>Fair</i>	<i>Medium/medium</i>	<i>This technology is likely to be ineffective for NAPL-impacted areas. Dewatering may be required in order to install an effective SVE system at the Site as a result of the high water table. This technology may not be effective for semi-volatile organic compounds (SVOCs) and PAHs, and would not be effective for arsenic.</i>
	<i>In-situ thermal</i>		<i>Variety of heating methods to promote heat to vaporize water and contaminants trapped in relatively conductive regions. The heat dries out the soil, causing it to fracture. These fractures make the soil more permeable. Vapors are recovered and treated, as needed, prior to discharge to the atmosphere.</i>	<i>Technically implementable</i>	<i>Potential</i>	<i>Fair</i>	<i>High/NA</i>	<i>This technology may potentially be applicable for source zone treatment at the site, removing more volatile contaminants, leaving relatively stable and immobile contaminants in place, although full-scale application may be cost-prohibitive. More cost-effective in-situ treatment of soil COCs is available.</i>
	<i>In-situ hot water/steam flushing</i>	<i>Steam injection and SVE</i>	<i>Steam or hot water is forced into soils through injection wells to enhance the mobilization of NAPL to collection systems. Steam injection also will vaporize volatile and semi-volatile contaminants which are removed from the vadose zone by vacuum extraction and then treated.</i>	<i>Technically implementable</i>	<i>Potential for volatile and semi-volatile organic compounds</i>	<i>Fair</i>	<i>High/high</i>	<i>The non-homogeneity of the fill and the presence of shallow water table conditions would likely limit the effectiveness of this technology. Would require hydraulic modeling to ensure capture of mobilized product and volatilized material. High energy usage may be cost-prohibitive. More cost-effective in-situ treatment of soil COCs is available.</i>
	Stabilization/solidification (S/S)	Auger/ caisson system	Constituents are physically bound within a stabilized mass (solidification), or chemical reactions are induced to reduce contaminants' mobility (stabilization). These systems are used to apply S/S reagents to soils. Reagents and dosage used is the primary design considerations.	Technically implementable	Potential	Good	Medium/NA	This technology is retained for inclusion in remedial alternatives. S/S can reduce the mobility of organic and inorganic contaminants and provides a decreased exposed surface area across which contaminant loss may occur.
	In-situ chemical oxidation (ISCO)*	Fenton's reagent or sodium persulfate	ISCO is a group of technologies that employs various combinations of oxidants and delivery techniques to mineralize contaminants. Oxidants may include hydrogen peroxide, potassium and sodium permanganate, sodium persulfate, and ozone. Oxidant chemicals are injected directly into the source zone and downgradient plume. Multiple injections may be required to achieve remediation goals.	Technically implementable	Potential (to be determined following completion of bench testing)	Fair	Med-high/Low	This technology may be capable of reducing contaminant concentrations at the Site. Low permeability soils and the presence of NAPL may limit the effectiveness of this technology. Chemical oxidation is typically applied to dissolved phase contaminants and residual non-mobile product (particularly lighter end petroleum products), and is typically used in combination with other technologies at NAPL sites where it has been applied. In-situ oxidation changes the redox conditions in the subsurface and the effect on all constituents of concern at the site should be evaluated prior to implementation.
In-Situ Treatment	Phyto-remediation/Bioremediation*		Phytoremediation/bioremediation uses plants and microbes associated with the plant root system to stabilize, degrade, or extract contaminants from the soil and groundwater by either adsorption or absorption. These processes can work for both inorganic and organic contaminants depending on the type of plant uses. Generally, this treatment works on low levels of contamination and works best when combined with other treatment remedies.	Potentially implementable	Potential	Fair	Low/Low	This technology may be capable of reducing low levels of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and providing stabilization of extraction of metals. A potential air hazard may arise if contaminants are volatilized without being fully metabolized by the plant. Additionally, if metals are absorbed into the plant, it may be a biological hazard to surrounding wildlife and residents unless the plants are harvested and disposed offsite. Treatment time and space may limit the applicability of this technology to the Site.

TABLE 3-2
Technology/Process Options for Operable Unit 1 – Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/O&M Cost	Screening Comments
Excavation and Ex-Situ Treatment	High-temperature desorption	Offsite high-temperature thermal desorption	High temperatures, 870 to 1,200 °C (1,400 to 2,200 °F), are used to volatilize and combust (in the presence of oxygen) halogenated and other refractory organics in hazardous wastes. Often auxiliary fuels are employed to initiate and sustain combustion. Off gases and combustion residuals generally require treatment.	Technically implementable	Demonstrated for organic constituents	Fair	High/NA	The need for excavation and off-site transportation to a permitted high-temperature desorption facility and associated truck traffic through metropolitan areas may preclude the use of this technology as a full-scale soil remedy, although it may be feasible for source zone treatment. However, more cost-effective offsite treatment technologies are available.
	Soil washing		Ex site soil washing involves dissolving or suspending contaminants in a wash solution. Wash water is augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics. It does not destroy or immobilize the contaminants. Consequently, the resulting concentrated wash water must be treated for disposal.	Technically implementable	Potential	Fair	High/medium	Complex mixture of contaminants in the soil (such as a mixture of metals, PAHs, and SVOCs) and heterogeneous contaminant compositions throughout the soil mixture make it difficult to formulate a single suitable washing solution that will consistently and reliably remove all of the different types of contaminants; therefore, this technology was not retained for further evaluation.
	Stabilization/solidification*	Asphalt batching	Constituents are physically bound within a stabilized mass (solidification), or chemical reactions are induced to reduce contaminants' mobility (stabilization). Ex-situ forms of this technology may include asphalt batching or incorporation of contaminated soil in concrete. Asphalt batching technologies have been applied to tar soils.	Potentially implementable	Potential for PAHs	Fair	High/NA	Ex-situ stabilization/solidification may require dewatering to allow excavation of contaminated soil below the water table. Asphalt batching with subsequent reuse has been applied successfully at other sites for tar-impacted soils. Geotechnical properties of the final processed material will need to be considered during the feasibility study process.
	Landfarming or Biopiles		Landfarming and biopiles are full-scale bioremediation technologies, which usually incorporates liners and other methods to control leaching of contaminants during biological treatment. Landfarming requires excavation and placement of contaminated soils, sediments, or sludges in lined beds that are periodically turned over or tilled to aerate the waste. Soil conditions are typically controlled to optimize the rate of contaminant degradation. Biopile treatment is similar to landfarming, but requires less area because the piles can be constructed to heights of ten feet or more. Excavated soils are mixed with soil amendments and placed in a treatment area that includes leachate collection systems and some form of aeration. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.	Potentially implementable – would require suitable offsite location	Potential	Low	Medium/Low	Not applicable on-site due to space limitations, the close proximity of commercial and residential facilities, presence of NAPL in the soils, and shallow groundwater conditions. Excavated waste would likely have to be treated at another location or be performed with engineering controls in place to prevent unacceptable impacts to the community. Ex-situ treatment technologies more likely to be effective and with fewer impacts to the community are available for soil constituents of concern.
Excavation and Ex-Situ Treatment	Low-temperature desorption	Offsite low-temperature thermal desorption	Low-temperature thermal desorption involves heating soil to temperatures of up to 650°C (1,200°F) to volatilize and contaminants for subsequent removal from the air stream using control technology.	Technically implementable	Demonstrated for organic constituents	Fair	High/NA	This technology may be included in a soil remedial alternative involving excavation and ex situ treatment. Soils typically require rendering prior to treatment. Clay and silt and high moisture content can affect effectiveness of the technology. On-site desorption may not be feasible due to permit requirements and the proximity of residential and commercial facilities to the Site.

TABLE 3-2
Technology/Process Options for Operable Unit 1 – Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Disposal	<i>Onsite reuse</i>	<i>None</i>	<i>This technology involves reusing treated soil onsite as backfill after reuse requirements are met. Soil containing NAPL may be reused as asphalt for certain applications.</i>	<i>Technically implementable</i>	<i>Demonstrated</i>	<i>Fair</i>	<i>Low/NA</i>	<i>Excavated soil would likely be treated offsite. Administrative implementability for this disposal option is lower than for offsite disposal and import of clean fill to the site.</i>
	Offsite Disposal	Landfill	This technology involves the removal of contaminated material for disposal in a permitted landfill.	Technically implementable	Demonstrated	Good	Medium/ Low	This disposal option may be included in alternatives involving excavation and/or treatment of impacted soil.

Notes:

Italicized and bolded text indicates technology or process option was screened from further consideration.

* Innovative Application of Technology

SVE –soil vapor extraction

ISCO – in-situ chemical oxidation

NAPL – non-aqueous phase liquid

NPL – National Contingency Plan

PAH – polycyclic aromatic hydrocarbon

RAO – remedial action objective

SVOC – semi-volatile organic compound

VOC – volatile organic compound

TABLE 3-3
Technology/Process Options for Operable Unit 1 – Groundwater Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Action	No Further Action	None	No action.	Not implementable – does not meet RAOs	Poor	Poor	NA/NA	Required for comparison by National Contingency Plan (NCP); does not meet remedial action objectives (RAOs).
Institutional Controls	Institutional Controls	Classification Exception Area (CEA)	Restrict access to contaminated groundwater by establishing a CEA whose purpose is to designate that constituents exceed water quality standards and ultimately prevent use of the affected aquifer for potable and/or other purposes.	Technically implementable	Good	Good	Low/Low	Does not meet RAOs when implemented alone; may be applicable in conjunction with other technologies.
Containment	In-situ Barrier wall		Encapsulation involves isolating impacted groundwater to cut off migration pathways between the contaminants and potential human and ecologic receptors. This typically involves constructing a low permeability barrier wall around the impacted area to prevent groundwater from entering or exiting the encapsulated area. Capping the soil to reduce infiltration is often combined with barrier wall technology.	Limited by existing structures	Demonstrated	Fair	High/low	In-situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment technology (see below) to create a funnel and gate directing groundwater flow through the treatment area.
	In-situ Passive Treatment Barrier*	Permeable reactive barrier (PRB)	Passive treatment wall technology provides for in-situ treatment of dissolved-phase constituents in shallow groundwater prior to discharge offsite. Designs for this technology typically consist of air sparging, zero-valent iron, biological stimulation, or other process options.	Technically implementable	Demonstrated	Good	High/low	Passive treatment barrier technology may be applicable to reduce dissolved-phase constituent concentrations and can be combined with barrier wall to create a funnel and gate configuration to direct groundwater flow through the treatment area.
	Subaqueous Reactive Barrier*		A mat consisting of reactive material(s) is encapsulated in a nonwoven core matrix bound between two geotextiles and installed in the area of the river where groundwater is discharging through the sediments. The subaqueous reactive barrier provides a reactive material that treats contaminants which are carried by advective or diffusive flow of groundwater into the adjacent river.	Technically implementable	Demonstrated	Good	Medium/low	This passive treatment technology may be capable of treating the groundwater prior to discharging to the Hudson River through the river sediments.
	Evapo-transpiration		<i>An evapotranspiration cover is composed of soil and plants selected to maximize the available storage capacity of soil, evaporation rates, and transpiration processes of plants to minimize water infiltration. Hydraulic control can be established by planting vegetation or trees that establish a large root mass at the water table and take up large quantities of water.</i>	Potentially implementable	Potential	Fair	Low/low	<i>Effectiveness may vary seasonally, and sufficient plant growth may be difficult to establish in portions of the Site due to existing contamination (such as the presence of NAPL). Hydraulic control alone does not reduce contaminant concentrations or eliminate exposure pathways.</i>
Monitored natural attenuation	Sampling and Analysis		Natural attenuation is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation. Only unaugmented natural processes are relied upon under this technology.	Technically implementable	Good	Good	Low/low	This technology may be capable of reducing residual organic contaminant concentrations and thereby economically reduce ecological and/or human health risk after source zone treatment or removal.

TABLE 3-3
Technology/Process Options for Operable Unit 1 – Groundwater Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In-Situ Treatment	In-situ Air Sparging and Soil Vapor Extraction (AS/SVE)		In-situ air sparging is a technology in which air is injected through a contaminated aquifer. Injected air strips contaminants out of impacted groundwater by volatilization. Volatilized contaminants migrate into the unsaturated zone where they can be extracted by an SVE system and treated or sequestered. The oxygen added during the sparging process can also enhance biodegradation of contaminants below and above the water table. Air sparging is typically applied to contaminants with low boiling points and high vapor pressures.	Technically implementable	Potential – VOCs and some SVOCs	Fair	Medium/medium	Dewatering may be required in order to install an effective SVE system at the Site as a result of the high water table. This technology may not be effective for high molecular weight semi-volatile organic compounds (SVOCs), and would not be directly effective for arsenic, although changes in redox conditions as a result of sparging may have an effect on the dissolution of arsenic in groundwater.
	In-situ Chemical Oxidation (ISCO)*		ISCO is a group of technologies that employs various combinations of oxidants and delivery techniques to mineralize contaminants. Oxidants may include hydrogen peroxide, potassium and sodium permanganate, sodium persulfate, and ozone. Oxidant chemicals are injected directly into the source zone and downgradient plume. Multiple injections may be required to achieve remediation goals.	Technically implementable	Potential	Good	Med-high/low	This technology may be capable of reducing contaminant concentrations at the Site. Low permeability soils may limit the effectiveness of this technology. Chemical oxidation is typically applied to dissolved phase contaminants and residual NAPLs (particularly lighter end petroleum products), and is typically used in combination with other technologies at NAPL sites where it has been applied. In-situ oxidation changes the redox conditions in the subsurface and the effect on all constituents of concern at the site should be evaluated prior to implementation. Dust control and safe handling of oxidants is an important consideration during implementation of this technology.
	Phyto-remediation/ Bioremediation*		<i>Phytoremediation/bioremediation uses plants and microbes associated with the plant root system to stabilize, degrade, or extract contaminants from the soil and groundwater by either adsorption or absorption. These processes can work for both inorganic and organic contaminants depending on the type of plant uses. Generally, this treatment works on low levels of contamination and works best when combined with other treatment remedies.</i>	Potentially implementable	Potential	Fair	Low/low	<i>This technology may be capable of reducing low levels of volatile organic compounds (VOCs), SVOCs and providing stabilization of extraction of metals. A potential air hazard may arise if contaminants are volatilized without being fully metabolized by the plant. Additionally, if metals are absorbed into the plant, it may be a biological hazard to surrounding wildlife and residents unless the plants are harvested and disposed offsite. Treatment time and space may limit the applicability of this technology to the Site.</i>
Ex-situ treatment	Groundwater extraction and treatment	(Treatment train TBD)	Extracted groundwater and/or vapor are treated onsite at a treatment facility which may include more than one process option to remove or degrade contaminants. Process options may include air stripping, activated carbon adsorption, separation, oxidation, bioreactors, scrubbers or other technologies selected based on the profile of the influent water and/or vapor.	Technically implementable	Good	Fair	Medium-high/high	These technologies may be included in any remedial alternatives involving the extraction or removal of vapor or groundwater that does not already meet discharge or disposal requirements. Pretreatment would be required to remove NAPL, turbidity, heavy metals, and/or insoluble oils from the influent stream.

TABLE 3-3

Technology/Process Options for Operable Unit 1 – Groundwater Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Disposal	Reinjection		<i>This technology involves injection of treated groundwater back into the unconfined aquifer at the site. Treatment requirements will be based on any applicable permitting requirements.</i>	<i>Technically implementable</i>	<i>Potential</i>	<i>Fair</i>	<i>Low/NA</i>	<i>This disposal option may be included in alternatives involving on-site ex situ groundwater treatment. Due to the proximity to the Hudson River and shallow groundwater, this technology would have a similar effect as discharge to surface water. Implementation is more difficult than surface water discharge. This technology is not retained because the effect would be similar to the retained surface water discharge technology but is more difficult to implement.</i>
	Surface Water Discharge		This technology involves discharge of treated groundwater into the Hudson River adjacent to the site. Treatment requirements will be based on the selected discharge location and any applicable permitting requirements.	Technically implementable	Good	Fair	Low/NA	This disposal option may be included in alternatives involving on-site ex situ groundwater treatment. Regulatory and community acceptance of this process option may be difficult to obtain.
	Publicly Owned Treatment Works (POTW)		This technology involves discharge of treated groundwater into the Edgewater sewer system flowing to the local POTW. Treatment requirements will be based on the selected discharge location and any applicable permitting requirements.	Technically implementable	Good	Fair	Low/NA	This disposal option may be included in alternatives involving on-site ex situ groundwater treatment.

Notes:

Italicized and bolded text indicates technology or process option was screened from further consideration.

* Innovative Application of Technology

AS/SVE – air sparging/soil vapor extraction

CEA – Classification Exception Area

ISCO – in-situ chemical oxidation

NAPL – non-aqueous phase liquid

NPL – National Contingency Plan

PAH – polycyclic aromatic hydrocarbon

POTW – publicly-owned treatment works

RAO – remedial action objective

SVOC – semi-volatile organic compound

TBD – to be determined

VOC – volatile organic compound

SECTION 4

Development of Alternatives

A range of six remedial action alternatives was developed from combinations of remedial technologies and process options that remained after screening (in Section 3). The assumptions, estimates of impacted media volumes, and treatment process conceptual design components were generated for each alternative for +50/-30 percent level cost estimating (Appendix C). Other viable process options within remedial technologies that achieve the same objectives may be evaluated during remedial design. The results of pre-remedial design investigations, treatability studies, and the remedial design will be used to specify the exact components of the selected alternative.

The Quanta property will likely undergo redevelopment activities sometime in the future that may require the site grade to change. It is likely that fill will be added to the property in order to make the property more suitable for development. Project financing requires all buildings to be above the 100-year floodplain. It is estimated that raising the existing grade by 2 to 10 feet would bring the elevation of the site into alignment with surrounding properties. Although the placement of the fill may be needed to meet the objectives of a future site development project, the placement of additional fill material will not be considered a component of the remedial alternatives in the FS, since it is not needed to achieve the RAOs for the site. For purposes of this FS, it is assumed that the alternatives that include placement of an engineered cap will be developed to achieve the RAOs based on current site conditions. If a development plan is available prior to implementation of the selected remedial alternative, modifications to the design of the engineered cap may be proposed to incorporate the fill that would be placed into an equivalent cap that provides the same level of protectiveness.

Backfilling and compaction are considered the most important redevelopment activities that have the potential to affect NAPL mobility at the site. Because the following alternatives were developed to address the NAPL zones identified as principal threats, NAPL impacted by the placement of fill would be low-level threat waste (i.e., NAPL in NZ-3 and NZ-4) that remains after implementation of the remedial alternatives.

Consolidation of the subsurface sediments as a result of the placement of fill will cause temporary fluid displacement and shifts in lithologic interfaces. Consolidation of the deeper silty-clay confining unit as a result of the placement of fill will cause displacement of pore fluids as void space is compressed. The displaced fluids will be expelled and drained into the overlying fill or sand until such time the displaced water equalizes. Displaced fluids may include a fraction of NAPL if it is present in the compressible unit; however, due to significantly higher conductivity for groundwater than for NAPL, it is assumed that groundwater will be the primary fluid that is displaced during this relatively short time period for equalization.

Impacts on the mobility of NAPL above these compressible units can also occur as a result of the placement of fill. NAPL seepage velocities may increase as a result of increases in NAPL gradients, either as the result of increases in hydraulic gradients caused by the

displacement of water from the compressible soils (short-term effect) or as the result of uneven shifts in lithologic interfaces (potentially long term). In the latter condition, settlement of the subsurface may reduce or increase the slope of the fill, or native sands where NAPL is present through nonuniform settlement of the underlying silty-clay or organic silts. This could result in either an increase or decrease in NAPL gradients. The degree to which this would occur will depend on the extent and intensity of filling. Despite the potential for temporary increases in NAPL gradients deeper inland, NAPL (e.g., NZ-3) will remain vertically and laterally contained by the silty-clay and nearshore organic silt deposits.

One objective of the SRI is to characterize groundwater flow paths and distribution and fate and transport of COCs across the groundwater-surface water transition zone(s) between OU1 and OU2. The results of the SRI and OU2 baseline ecological risk assessment (BERA) will provide information necessary to evaluate the preferential groundwater discharge areas in OU2 and associated ecologic risk that may be present from groundwater that is upwelling to the river. Potential migration of COCs from OU1 to OU2 and unacceptable risks posed by this potential migration will be addressed as necessary by the groundwater remedy. The remedial action described in this section is conceptual in nature and finalization is pending the completion of ongoing evaluations. The technology to be implemented will be described in the draft final FS, and the precise size, location, material, and configuration of the technology implemented will be determined during remedial design. The final design of the groundwater component for OU1 will be modified as necessary to address the ecological risks as identified during the OU2 BERA.

Five active alternatives vary in how they mitigate potential risks posed by principal threat and low-level threat waste (and are named accordingly). All five active alternatives include the following components to achieve RAOs for nonsource material, indoor air, and groundwater:

- Soil capping
- Institutional controls to prevent exposure of COCs in soil and groundwater
- Vapor intrusion mitigation at the 115 River Road building and at other buildings if needed
- An SRB to treat groundwater discharging to the Hudson River

4.1 Alternative 1—No Further Action

Under this alternative, there would be no additional remedial actions conducted at the site. There would be a potential human health risk in surface soil (0–2 feet bgs) and subsurface soil (0–10 feet bgs) from direct contact with free-phase NAPL. There would be no additional remedial actions conducted at the site to control or remove COCs or NAPL, or to prevent exposure. No further remedial action would be taken for groundwater, and COCs in groundwater could continue to reach the Hudson River. Vapor intrusion mitigation would not be provided for 115 River Road or other buildings. Alternative 1 does not include monitoring or institutional controls. The objective of Alternative 1 is to provide a baseline for comparison to other alternatives, as required by the NCP.

4.2 Alternative 2—Containment

Alternative 2 combines free-phase NAPL recovery from NZ-1, NZ-2, and NZ-5 using recovery wells and trenches, a PRB or funnel and gate to protect the river from NAPL, soil capping, and in situ treatment of dissolved COCs in groundwater discharging to the Hudson River by means of an SRB. This alternative also includes maintaining existing roads, parking surfaces, and the arsenic cap. Engineering controls that would reduce the potential for vapor intrusion under future conditions are incorporated into this alternative, along with institutional controls to prevent exposures to soil or groundwater.

Alternative 2 addresses principal threats identified in Section 1.10 are described below and shown in Table 4-1:

- Toxicity potential due to direct human contact with source material (principal threat waste for NZ-1, NZ-2, tar boils, and the HCAA on the Quanta property and Block 93 North) is addressed by eliminating the direct contact exposure pathway through capping and institutional controls. In addition, tar boil formation is reduced through recovery of free-phase NAPL from NZ-1 and NZ-2.
- The unoccupied basements of 115 River Road are converted to crawl spaces with new subslabs, vapor barriers, and active ventilation. Other occupied buildings will be sampled periodically, and if vapor intrusion is identified, mitigation will be provided as needed. Toxicity potential for ecological receptors at OU2 (principal threat risk at NZ-2 and NZ-5) is reduced through the installation of a funnel-and-gate system or PRB to isolate the NAPL zones from the Hudson River.
- Mobility potential for free-phase NAPL (principal threat risk at NZ-2 and NZ-5) is reduced through NAPL recovery and a funnel-and-gate system or PRB to isolate the NAPL zones from the Hudson River.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of an SRB. Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable, as described in Section 2.5; however, fate and transport evaluations presented in the final RI (CH2M HILL, 2008a) indicate that the contaminant plume is stable.

The following subsections briefly describe the components of Alternative 2.

4.2.1 Non-Aqueous Phase Liquid

Free-phase NAPL would be recovered, to the extent practicable, from recovery wells and trenches as shown in Figure 4-1. For purposes of this FS, the NAPL recovery system is assumed to include 14 recovery wells and two recovery trenches installed in OU1 at locations where principal threat NAPL has been identified. NAPL recovery will reduce the formation of tar boils and mitigate the potential for NAPL migration in nearshore areas. The exact number of recovery wells and trenches and their configuration would be finalized during the design phase of the work, should this alternative be selected. Figures 4-2 through 4-5 depict this alternative in cross section view.

Recovery Wells

Recovery well construction would likely consist of a 24-inch-diameter borehole with an 8-inch stainless steel well extending through the NAPL zones. The base of the well will be grouted to act as a sump for product accumulation and to prevent the migration of product. Because the physical characteristics of the NAPL at the site vary, different methods of product removal would be required to optimize the effectiveness of this alternative. It has been assumed that half of the wells would be outfitted with manually operated product-only recovery pumps. The other half would require manual bailing due to the high viscosity of the NAPL, which would render pumping impracticable or impossible. NAPL recovery wells would be monitored periodically to measure the accumulated thickness of free-phase NAPL. If measurable amounts of NAPL are present, the product-only pumps would be manually activated and the remaining locations manually bailed.

Recovery Trenches

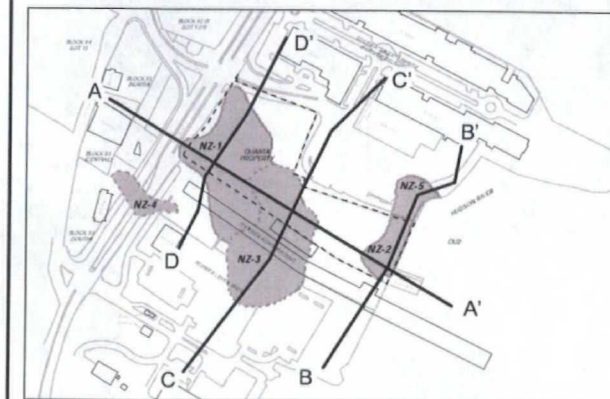
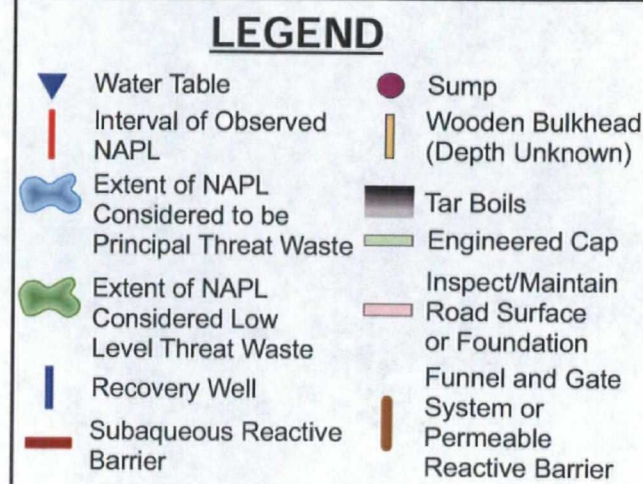
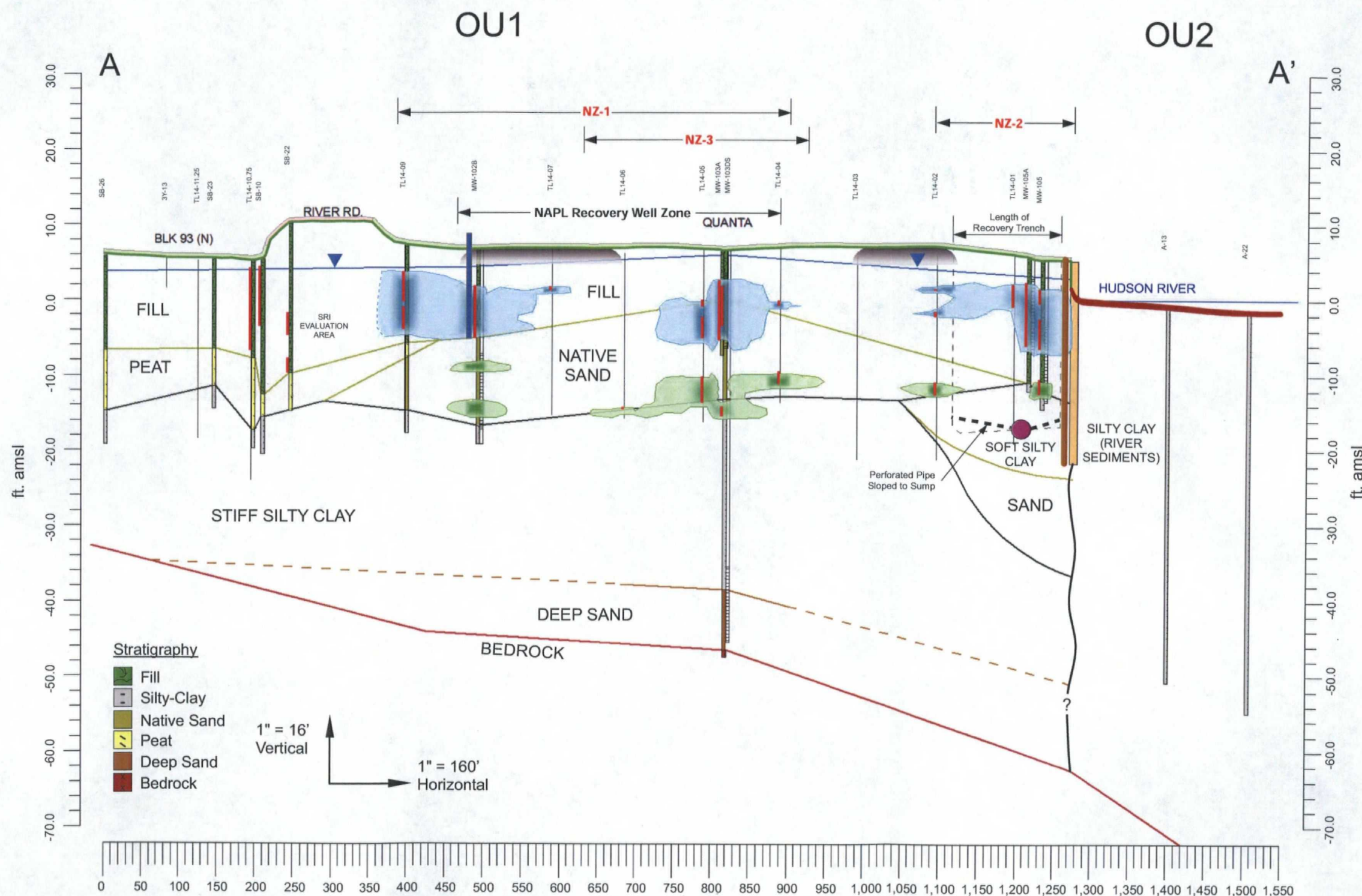
The recovery trenches are assumed to consist of high-permeability material (such as granular fill), with extraction wells similar to the recovery wells spaced at regular intervals within the trenches. NAPL recovery trenches would be installed to the depth of the silty clay layer and stabilized, if needed, to prevent collapse. The recovery trench may be installed deeper into the silty clay layer to improve recovery. The depth would be finalized during remedial design. During construction, trenches and excavated soil would be covered with tarps or tents fitted with blowers and vapor treatment units to recover and treat vapors from the excavation and reduce infiltration of precipitation into the trenches. Water removed from the trench during construction would be containerized and a portion would be used to create the polymer slurry for trench construction. Any remaining groundwater would be disposed of offsite.

Recovered NAPL would be extracted from the recovery trench sumps using product-only pumps or bailing, depending on NAPL viscosity. If the viscosity of the NAPL collected in the sump is too high for the automated pumps, the NAPL may be manually bailed or removed by a vacuum truck. It is assumed for the FS that an automated pumping system would be used to extract NAPL from the sumps. The pumps (top-head-drive, positive-displacement piston pumps similar to those available from Blackhawk Technology Company, Glen Ellyn, Ill.) would sense the level of NAPL that has collected in the sump. When a sufficient volume of NAPL has accumulated, the NAPL would be pumped to the surface for collection.

Offsite Treatment/Disposal

NAPL from the recovery wells would be collected in 55-gallon drums. NAPL collected from the recovery trench sumps would be pumped through double-walled piping to storage tanks with leak detection capability. The storage tanks and drums would be located within centralized sheds with secondary containment adequate to contain a spill from failure of the tanks/drums. The sheds would also house backup equipment and the control panels for the recovery wells. The control panels would be remotely accessible and have alarm systems tied to an autodialer that would notify the system operator of high product levels in the tanks or any system problems.





Note:

- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- Conceptual model of OU1 and OU2 boundary depicted.
- Trench shown parallel to cross-section line. Trench width will be 3-4 ft.
- ft. = feet
amsl = above mean sea level

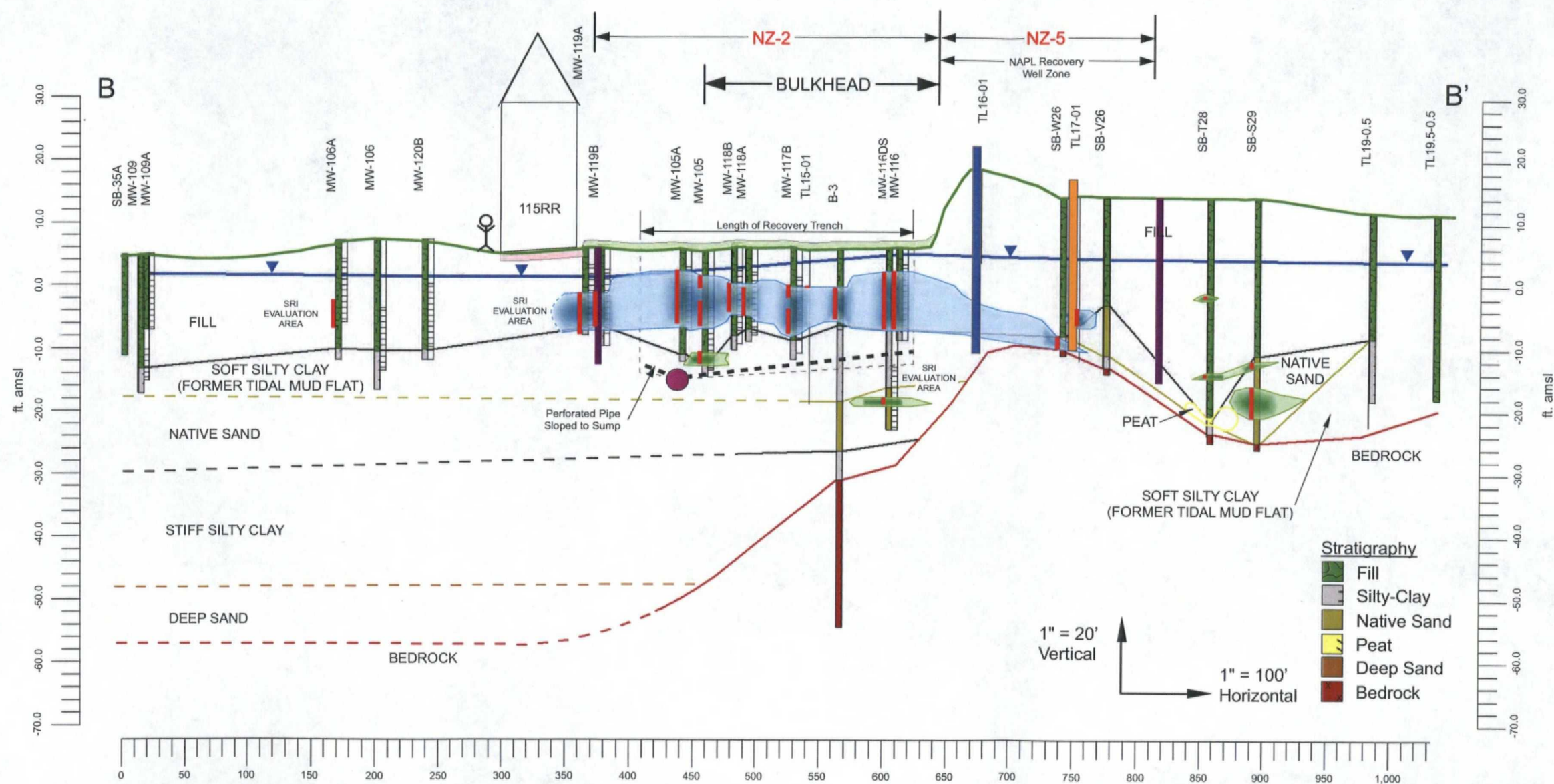


**ALTERNATIVE 2
CROSS-SECTION A - A'**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

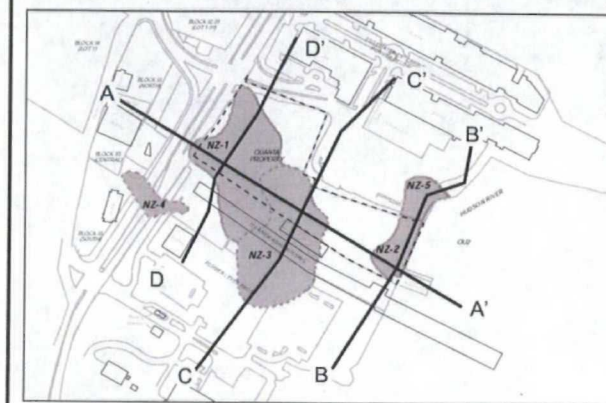
December 19, 2008

FIGURE 4-2



LEGEND

- | | |
|--|---|
| Water Table | Engineered Cap |
| Interval of Observed NAPL | Inspect/Maintain |
| Extent of NAPL Considered Principal Threat Waste | Road Surface or Foundation |
| Extent of NAPL Considered Low Level Threat Waste | Funnel and Gate or Permeable Reactive Barrier |
| Sump | Recovery Well |
| | Sentinel Well |



Plan view of the Quanta Resources Superfund Site

Note:

- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- Final extent of NZ-2 will be determined based on results of SRI investigation.
- ft. = feet
- amsl = above mean sea level
- Trench shown parallel to cross-section line trench width will be 3-4 ft.
- 115 River Road dimensions are estimated.

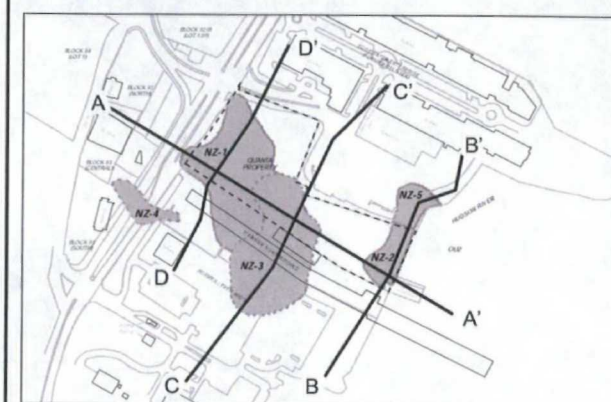
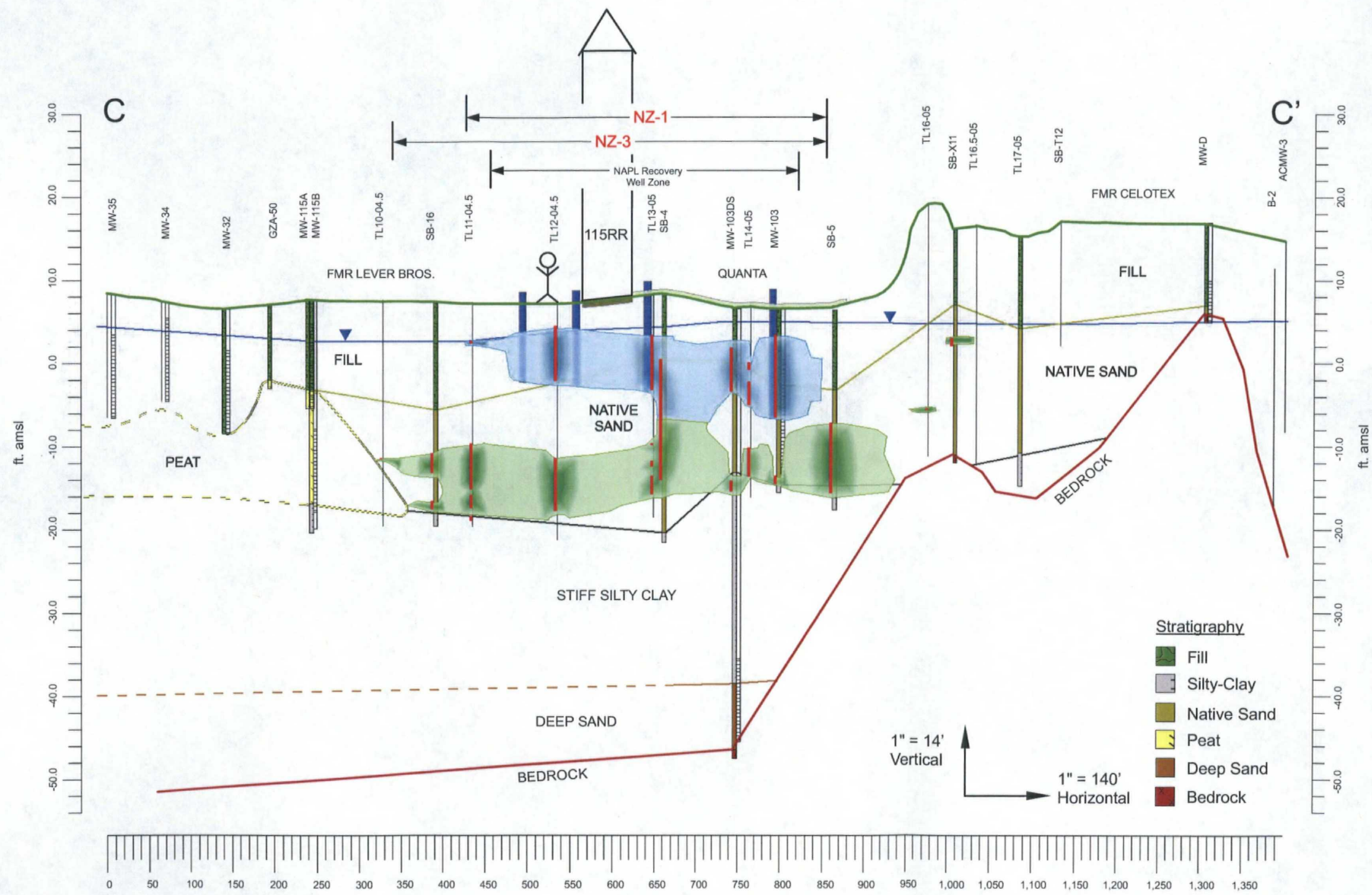


ALTERNATIVE 2 CROSS-SECTION B - B'

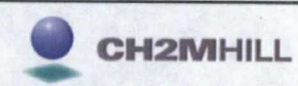
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

FIGURE 4-3



- Notes:**
- Extent of NAPL is not representative of recoverable NAPL.
 - Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
 - Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
 - Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
 - Water table elevation depiction based on synoptic measurements taken in October 2006.
 - Dashed lithology lines are inferred from data and observations.
 - ft. = feet
 - amsl = above mean sea level
 - 115 River Road dimensions are estimated.



ALTERNATIVE 2 CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

FIGURE 4-4

TABLE 4-1
Principal Threat Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Principal Threat Definition ^a										
Source Area	Mobility Potential	Toxicity Potential		Principal Threat Waste?—Summary	Alternative					
		Accessibility/ Proximity to Receptors	Vapor Intrusion		2—Containment	3—Excavation and Containment	4—Solidification/Stabilization	5—In Situ Treatment	6—Excavation and Offsite Disposal	
Principal Threat Waste	NZ-1	Low —High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to a maximum depth of 11 feet bgs. Further migration of NAPL in this zone is not predicted to occur, based on the physical characteristics of the NAPL and the likely age of release(s) that resulted in the presence of NAPL at this location. At an isolated area, NAPL has migrated to the depth of the silty-clay confining unit (approx. 25 feet bgs). At this location, further migration is prevented by the presence of the silty-clay confining unit.	High —NAPL containing COCs is present at depths posing a risk of direct contact.	High —NAPL zones containing COCs that are present near existing or future buildings pose a risk of vapor intrusion.	Yes —Toxicity Potential	Toxicity Potential —The direct contact exposure pathway is eliminated through capping and institutional controls. Vapor intrusion mitigation will be installed in basements of occupied building (115 River Road) and as needed in other occupied buildings.	Toxicity Potential —The direct contact exposure pathway is eliminated through shallow excavation (to 4 feet bgs), capping and institutional controls. Vapor intrusion mitigation will be installed in basements of occupied building (115 River Road) and as needed in other occupied buildings.	Toxicity Potential —The direct contact exposure pathway is addressed through the use of in-situ solidification/stabilization, which mitigates potential risk by sequestering COCs. Vapor intrusion mitigation will be installed in basements of occupied building (115 River Road) and as needed in other occupied buildings. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Toxicity Potential —The direct contact exposure pathway is eliminated through shallow excavation (to 4 feet bgs) , in-situ treatment (likely chemical oxidation) and institutional controls. Vapor intrusion mitigation will be installed in basement of occupied building (115 River Road) and as needed in other occupied buildings.	Toxicity Potential —The direct contact exposure pathway is addressed through the excavation and offsite disposal of principal threat source material in NZ-1, and institutional controls. Vapor intrusion mitigation will be installed in basements of occupied building (115 River Road) and as needed in other occupied buildings.
	NZ-2	Conservatively Assumed High —High viscosity and interfacial tension have generally limited the migration of NAPL to approximately 14 feet bgs, and further migration under current conditions is unlikely. In light of the remaining uncertainty in this area with regard to a discrete interval of deeper NAPL observed at MW-116DS and the unknown vertical extent of the wooden bulkhead, additional investigation is currently being conducted. However, the remedial alternative development, evaluation, and selection conservatively assume that the potential for NAPL migration between OU1 and OU2 should be addressed at NZ-2.	High —NAPL containing COCs is present at depths posing a risk of direct contact, and NAPL is present adjacent to the Hudson River (ecological receptors).	High —NAPL zones containing COCs that are present near existing or future buildings pose a risk of vapor intrusion.	Yes —Potential Mobility and Toxicity	Mobility Potential —Potential NAPL migration to OU2 is prevented through the use of a NAPL recovery system and a funnel-and-gate system or permeable reactive barrier along the shoreline. Toxicity Potential —The direct contact exposure pathway is mitigated through capping and institutional controls	Mobility Potential —Potential NAPL migration to OU2 is prevented through the use of a NAPL recovery system and a funnel-and-gate system or permeable reactive barrier along the shoreline. Toxicity Potential —The direct contact exposure pathway is mitigated through shallow excavation (to 4 feet bgs), capping and institutional controls.	Mobility Potential —The potential for NAPL migration at NZ-2 is mitigated through in-situ solidification/stabilization. Toxicity Potential —The direct contact exposure pathway is addressed through the use of in-situ solidification/stabilization, which mitigates potential risk by sequestering COCs. Vapor intrusion will be mitigated by the in-situ solidification/stabilization of NAPL that restricts volatilization and constituent migration. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Mobility Potential —The potential for NAPL migration at NZ-2 is mitigated through shallow excavation, NAPL recovery (trenches), and in-situ treatment (likely chemical oxidation). Toxicity Potential —The direct contact exposure pathway is eliminated through shallow excavation (to 4 feet bgs), the use of in-situ treatment (oxidation) and institutional controls. Vapor intrusion will be prevented in-situ treatment.	Mobility Potential —The potential for NAPL migration at NZ-2 is mitigated through the excavation and offsite disposal. Toxicity Potential —The direct contact exposure pathway at NZ-2 is mitigated through the physical removal and offsite disposal, and institutional controls. Vapor intrusion will be prevented by the removal of NAPL in NZ-2.

TABLE 4-1
Principal Threat Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Principal Threat Definition ^a		Toxicity Potential			Alternative				
Source Area	Mobility Potential	Accessibility/ Proximity to Receptors	Vapor Intrusion	Principal Threat Waste?— Summary	2—Containment	3—Excavation and Containment	4—Solidification/Stabilization	5—In Situ Treatment	6—Excavation and Offsite Disposal
Principal Threat Waste	NZ-5	Conservatively Assumed High —The available evidence supports the conclusion that most NAPL in this area is residual. However, due to the proximity of the NAPL to the Hudson River and the presence of sheens at OU2 near NZ-5, the remedial alternative development, evaluation, and selection conservatively assumes that the potential for NAPL migration between OU1 and OU2 should be addressed at NZ-5.	Medium —NAPL present adjacent to the Hudson River (ecological receptors); however, depth limits potential for direct contact.	Low —Depth of NAPL present limits potential for vapor migration.	Yes —Mobility and Toxicity Potential	Mobility Potential —Potential NAPL migration to OU2 is prevented through the use of NAPL recovery wells and a funnel-and-gate system or permeable reactive barrier along the shoreline. Toxicity Potential —Exposure of ecological receptors in the Hudson River is mitigated through the use of a funnel-and-gate system or permeable reactive barrier to isolate NZ-5 from the receptors. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Mobility Potential —Potential NAPL migration to OU2 is prevented through the use of NAPL recovery wells and a funnel-and-gate system or permeable reactive barrier along the shoreline. Toxicity Potential —Exposure of ecological receptors in the Hudson River is mitigated through the use of a funnel-and-gate system or permeable reactive barrier to isolate NZ-5 from the receptors. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Mobility Potential —Potential migration of NAPL to the Hudson River is prevented through the use of in-situ solidification/ stabilization at NZ-5. Toxicity Potential —Exposure of ecological receptors in the Hudson River is mitigated through the use of in-situ solidification/ stabilization and institutional controls.	Mobility Potential —The potential for NAPL migration at NZ-5 is mitigated through NAPL recovery (wells), and application of in-situ treatment. Toxicity Potential —Exposure of ecological receptors in the Hudson River is mitigated through the use of NAPL recovery and in-situ treatment and institutional controls.
	Tar Boils	Low —Solid, taffy-like tar in the near surface vadose zone has been observed to seep through surface cracks in soil or pavement on very hot days. However, this very high viscosity material is not present in quantities sufficient to migrate beyond the immediate vicinity of the tar boil.	High — Coal tar is present at the ground surface, posing a risk of direct contact.	Low —The presence of buildings would prevent the heating caused by sunlight that create this phenomenon.	Yes —Toxicity Potential	Toxicity Potential —NAPL extraction will remove free-phase material and limit the formation of tar boils, while capping reduces the potential risk of direct contact. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Toxicity Potential —Shallow excavation and NAPL recovery will remove free-phase material and limit the formation of tar boils, while capping reduces the potential risk of direct contact. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Toxicity Potential —The direct contact exposure pathway is addressed through the use of in-situ solidification/stabilization, which mitigates potential risk by sequestering COCs. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Same as Alternative 3. Toxicity Potential —The direct contact exposure pathway for tar boils is mitigated through the physical removal and offsite disposal of shallow NAPL. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.

TABLE 4-1
Principal Threat Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Principal Threat Waste		Principal Threat Definition ^a			Principal Threat Waste?—Summary	Alternative				
		Mobility Potential	Toxicity Potential			2—Containment	3—Excavation and Containment	4—Solidification/Stabilization	5—In Situ Treatment	6—Excavation and Offsite Disposal
			Accessibility/Proximity to Receptors	Vapor Intrusion						
HCAA (Quanta)	Low—Source material (pyritic ore) is not mobile.	High—Surface soil contains arsenic at concentrations posing an estimated Excess Lifetime Cancer Risk (ELCR) of 1 × 10 ⁻³ and a Hazard Index (HI) of 9, based on an exposure point concentration of 3,900 mg/kg. ^{b,c}	Low—Arsenic is not a vapor intrusion concern.	Yes—Toxicity Potential	Toxicity Potential—The direct contact exposure pathway is eliminated through capping and institutional controls.	Toxicity Potential—The direct contact exposure pathway is eliminated through the use of in-situ solidification/stabilization in all areas exceeding 336 ppm, which mitigates potential risk by sequestering COCs Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Same as Alternative 3.	Same as Alternative 3.	Toxicity Potential—The direct contact exposure pathway is addressed through the removal and offsite disposal, and institutional controls.	
	Low—Source material (pyritic ore) is not mobile.	HIGH- Surface soil contains arsenic at concentrations posing an estimated Excess Lifetime Cancer Risk of 3x10 ⁻⁴ and a Hazard Index of 2, based on an exposure point concentration of 913 mg/kg. ^{b,c}	Low—Arsenic is not a vapor intrusion concern.	Yes—Toxicity Potential	Toxicity Potential—The direct contact exposure pathway is eliminated through capping and institutional controls.	Toxicity Potential—The direct contact exposure pathway is eliminated through the use of in-situ solidification/stabilization in all areas exceeding 336 ppm, which mitigates potential risk by sequestering COCs Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Same as Alternative 3.	Same as Alternative 3.	Toxicity Potential—The direct contact exposure pathway is addressed through the removal and offsite disposal, and institutional controls.	

TABLE 4-1
Principal Threat Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Principal Threat Definition ^a					Alternative				
Source Area	Mobility Potential	Toxicity Potential		Principal Threat Waste?—Summary	2—Containment	3—Excavation and Containment	4—Solidification/Stabilization	5—In Situ Treatment	6—Excavation and Offsite Disposal
		Accessibility/Proximity to Receptors	Vapor Intrusion						
Low Level Threat Waste	NZ-3	Low —NAPL in NZ-3 has low viscosity and has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 feet bgs. Gravitational forces and the impermeability and surface topography of the confining layer prevent further downward and lateral migration of NAPL in this zone.	Low —NAPL contains COCs; however, depth limits potential for direct contact.	Low —Depth of NAPL present limits potential for vapor migration.	No	No action is taken to prevent leaching to groundwater from materials below the water table. Restoration of the groundwater to drinking water quality is considered technically impracticable; however, fate and transport evaluation indicates that the contaminant plume is stable. COCs in groundwater from OU1 that discharges in OU2 would be treated by a subaqueous reactive barrier. Institutional controls, including construction requirements, will establish criteria for future development that would minimize potential for vapor intrusion.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
	NZ-4	Assumed to Be Low —NZ-4 comprises shallow and deeper NAPL beneath Block 93 Central, Block 93 South, River Road, and the northwestern portion of the former Lever Brothers property. Potential migration of NAPL in NZ-4 is being evaluated as part of the ongoing OU1 SRI.	Low/Medium —NAPL contains COCs; however, depth may limit potential for direct contact.	Low —Depth of NAPL present limits potential for vapor migration.	Potential —Dependent on results from SRI				
Low Level Threat Waste	HCAA (Celotex)	Low —Source material (pyritic ore) is not mobile.	Low —Oxidizing pyritic waste material contains arsenic above applicable soil standards, however, the depth of the material limits the potential for direct contact.	Low —Arsenic is not a vapor intrusion concern.	No	The potential for arsenic to leach to groundwater from the HCAA on the Celotex property is eliminated through in-situ solidification/stabilization and institutional controls.	Same as Alternative 2.	Same as Alternative 2.	The potential for arsenic to leach to groundwater is eliminated through excavation and offsite disposal.

^a Defining areas as principal threat waste or low-level waste are based on *A Guide to Principal Threat and Low Level Threat Wastes* (EPA, 1991).

^b As presented in the Draft Human Health Risk Assessment (CH2M HILL, November 2007).

^c Receptor: future commercial worker

COC, constituent of concern; ELCR, excess lifetime cancer risk; HCAA, high-concentration arsenic area; HI, hazard index; NAPL, non-aqueous-phase liquid.

During a NAPL recovery test performed in July and August 2007, NAPL samples were collected from below the water table from five monitoring wells (MW-102A, MW-105, MW-116B, MW-107, and MW-112B). The chemical analysis results were evaluated to determine if the NAPL exhibited any of the hazardous characteristics identified in 40 CFR 261 Subpart C. Based on the comparison of the chemical analysis results and the maximum concentration of constituents for the toxicity characteristic (Table 1 of 40 CFR 261 Subpart C), it is likely that the NAPL collected would be considered a characteristic hazardous waste; therefore, the storage area on the Quanta property would need to comply with RCRA requirements for hazardous waste.

Offsite disposal options would be finalized during remedial design, and may include oil recycling or stabilization. For cost-estimating purposes, offsite disposal of NAPL is assumed to be via oil recycling.

It is anticipated that the soils excavated for installation of the NAPL recovery trenches would not meet TCLP limits. Onsite stabilization of soils would be necessary prior to their disposal to meet land disposal restrictions. Soil would be stockpiled, stabilized, and then disposed of at an offsite landfill. Details of sampling requirements for excavated soils, required treatment, and disposal options would be finalized during remedial design.

NAPL Containment

Treatment of nearshore principal threat NAPL (i.e., NZ-2 and NZ-5) potentially discharging to the river would be achieved by the installation of either a funnel-and-gate system (Figure 4-6) using sealed sheet piling and PRBs, or with a full PRB. The method of NAPL containment would be determined during remedial design. For cost estimation purposes, this FS assumes that a funnel-and-gate system would be installed. Installation of either system on the former Celotex property may be complicated by the presence of subsurface boulders that would need to be temporarily removed.

4.2.2 Arsenic-Contaminated Soil

Soil areas containing arsenic concentrations in excess of PRGs are located on the Quanta, Block 93 North, and the former Celotex properties. A portion of the Quanta and former Celotex properties at which concentrations of arsenic greater than 1,000 mg/kg have been detected in soil is covered with a multilayer engineered cap to prevent direct contact and infiltration. If Alternative 2 were implemented, the existing arsenic cap would remain in place. Inspection and maintenance of the area is required by AOC CERCLA-02-2003-2014 between EPA and Edgewater Enterprises, LLC. The capped area would continue to be inspected periodically to ensure that no breaches that could be sources of infiltration exist and that there is no possibility of direct contact with soil. The remaining arsenic areas located on the Quanta property would be capped with a multilayer vegetative cap and the areas on the Block 93 North property would be capped with a single-layer engineered cap, as described in Section 4.2.3 below.

4.2.3 Residual Soil

Areas where site-related constituents exceed PRGs in soil would be capped with an engineered cap to prevent direct contact, thereby eliminating the exposure pathway for this medium, and to prevent erosion of contaminated soil. The cap would be placed over the

Quanta property and the outdoor areas on the 115 River Road, Block 93 North, Block 93 Central, and Block 93 South properties, replacing existing asphalt or other material (Figure 4-1).

The cap for the former Quanta property would be a multilayer vegetative cap consisting of the following (from visible surface to top of existing soil):

- Vegetative and protective layer
- Geotextile filter fabric
- Drainage layer of granular soil
- HDPE liner
- Protective layer

Fill may be imported to bring the vegetative cap on the Quanta property up to the same elevation as the adjacent properties (i.e., former Celotex and 115 River Road properties) for redevelopment purposes; however this action is not considered a component of the alternative.

The cap for the 115 River Road, Block 93 North, Block 93 Central, and Block 93 South properties would be a single-layer engineered cap consisting of either a 4-inch-thick paved surface underlain by a 6-inch sub-base or a vegetative cap, depending on redevelopment. Cap design would be consistent with NJDEP (1998) guidance.

The current slab-on-grade and other building foundations on the 115 River Road, Block 93 North, Block 93 Central, Block 93 South, and Former Lever Brothers properties would remain in place as engineering controls, unless replaced in the future by similar or more protective surfaces. The existing surfaces of River and Gorge roads would also remain in place. These existing surfaces would be inspected and maintained to ensure their continued effectiveness as engineering controls. The basement of the 115 River Road building would be upgraded as described in Section 4.2.4, below.

4.2.4 Vapor

The basement areas of 115 River Road would be upgraded with engineered subslabs and converted to ventilated crawl spaces to eliminate the potential vapor intrusion pathway. The equipment and materials in the existing basements (i.e., miscellaneous office furniture, building supplies, etc.) would be removed and the sumps and drains abandoned (filled in place). Subsequently, 2 feet of fill material would be placed over the existing slab, followed by the installation of a vapor barrier (HDPE liner), and 2 feet of concrete. In addition, a sealant would be used along the perimeter and insulation would be installed on basement ceilings. The crawl space would be actively ventilated and sampled periodically to monitor vapor concentrations.

Vapor intrusion mitigation measures would be installed and/or maintained in other occupied buildings, if necessary, as determined by indoor air sampling or other vapor intrusion evaluations.

4.2.5 Groundwater

Subaqueous Reactive Barrier

COCs in groundwater from OU1 that discharges to the Hudson River, or OU2, would be treated by an SRB. The proposed use of the SRB for groundwater is a contingency component of the proposed remedial alternatives to address uncertainty related to the degree of attenuation of OU1 dissolved-phase constituents and residual NAPL, that could result in sheens, prior to their being discharged to OU2.

The SRB would consist of a permeable subaqueous reactive mat to treat COCs as the pore water discharges by advection through the sediments to the surface water of the river (Figures 4-6 and 4-7). The mat is assumed for cost estimating purposes to be placed over approximately 150,000 ft² of sediments in OU2 (Figure 4-7), however modeling would be required to design the extent and configuration required to mitigate potential risk.

SRBs can include geotextiles, liners, and other permeable elements in multiple layers that may include the addition of material to attenuate the flux of constituents (e.g., granular activated carbon or organoclay). Reactive core materials would be encapsulated between carrier textiles that adhere together to provide integrity. The groundwater that discharges to OU2 would be treated as it passes through the SRB. A model incorporating site-specific conditions is critical to predicting the expected feasibility effectiveness, and O&M requirements of the SRB. Bench-scale testing would be performed to assess the sorptive capacity of the cap material, which would act to decrease constituent flux through the cap. Reactive barrier treatment may be reversible if adsorption sites are completely used up, allowing desorption to occur. Monitoring of the SRB would be conducted to predict when replacement may be required.

The final design of the SRB including the size and material would be highly dependant on the findings of the SRI and OU2 BERA. Though it would need to be confirmed with bench-scale evaluations, it is anticipated that the SRB would consist of a combination of organoclay, apatite, and granular activated carbon. A layer of sand or sand-gravel mix would be placed over the SRB to hold it in place, along with the provision of an armor layer (i.e., rocks) to protect the SRB from hydraulic scour conditions due to storm surge flows, if deemed necessary based on the results of the OU2 sediment stability study

A bathymetric survey would be conducted after placement to establish a baseline elevation for the area within which the SRB is located. Additional surveys would be performed at 6 months and 18 months after placement to identify bathymetric changes. Coring and analysis of the SRB would be conducted periodically to determine the vertical profiles of COC concentrations in the SRB. This information would be used to determine when replacement of the SRB is required.

Groundwater Monitoring

Details of the groundwater monitoring frequency and post-remediation monitoring network (number of wells, sampling locations, constituent analysis list) would depend on the final remedial design. Once implementation of the remedy has begun, the monitoring network would be periodically reevaluated. Cost estimating assumptions made including the monitoring network and sampling frequency and analytes are included in Appendix C.

4.2.6 Institutional Controls

Land-Use Restrictions

Alternative 2 reduces exposure to impacted media left in place through placement of engineered caps and institutional controls. Institutional controls consist of land-use restrictions for all areas at which COCs remain in place in exceedance of PRGs in soil or groundwater. Deed notices for each impacted property would be prepared in accordance with the NJDEP *Technical Requirements for Site Remediation* (NJAC 7:26E). As part of the land use restriction, biennial certifications would be submitted to NJDEP while the engineering and institutional controls remain in place. Institutional controls would require that appropriate engineering controls are used to ensure the continued protection of human health and the environment before, during and after potential redevelopment.

Capped areas on each property would require periodic inspection by the respective property owner to ensure that no breaches that could be sources of infiltration and/or direct contact with soil are present. Institutional controls would necessitate construction techniques that limit the impact to the cap or require specific restoration to the functionality of the cap. Additional restrictions may be implemented to limit activities involving penetration of existing and newly installed caps and NAPL zones. Institutional controls would establish criteria for new construction and dictate that prior to construction of a building; a vapor intrusion evaluation would be conducted. Buildings would be required to be designed to address potential vapor intrusion risks. Institutional controls would also require that construction workers wear appropriate personal protective equipment (PPE) and that other measures be taken as necessary during redevelopment or other construction activities.

A portion of the Quanta and former Celotex properties where concentrations of arsenic greater than 1,000 mg/kg have been detected in soil is currently covered with a multilayer engineered cap to prevent direct contact and infiltration. If Alternative 2 were implemented, the existing arsenic cap would remain in place. The capped area would continue to be inspected periodically by the property owner to ensure there are no breaches that could be sources of infiltration or direct contact with soil. Inspection and maintenance of the area is required by AOC CERCLA-02-2003-2014 between EPA and Edgewater Enterprises, LLC.

Groundwater Use Restrictions

As part of this alternative, NJDEP would be requested to determine that a CEA is applicable to the groundwater at the Site in order to restrict groundwater use (NJAC 7:26E-8.4). The components of the CEA include the location of the restriction (which includes the potential migration locations before degradation reduces constituent concentrations to below applicable cleanup criteria), the compounds detected over the applicable cleanup criteria within the restricted area, and the proposed duration of the restriction. This designation would prohibit future use of the groundwater within this area and would restrict the installation of wells (other than monitoring wells) in the area for the duration of the CEA. The CEA would be submitted to and approved by NJDEP and placed within the New Jersey geographic information system database for the duration of the control. Reapplication for the CEA would be required every 10 years until the CEA is no longer required because of a reduction in COC concentrations below PRGs.

NJAC 7:9-6.6 states that the NJDEP may designate a CEA

...only when constituent standards are not, or will not be met due to (1) natural ground water quality; (2) localized effects of a permitted discharge (e.g., effluent limits above the constituent standards with discharge outside the plume/capture zone); (3) part of a pollution remedy conducted pursuant to an Administrative Consent Order or other Department oversight mechanism or program; or (4) an Alternate Concentration approved pursuant to the New Jersey Pollutant Discharge Elimination System (NJPDES).

According to the NJDEP CEA guidance,

CEAs are typically of limited duration and are related to the term of a permit approval or estimated time for completion of a remediation. In some cases (e.g., sites where ground water has been contaminated by metals from historic fill or other discharges), the Department may accept a proposal for a CEA of "indeterminate" longevity. If necessary, the term of a CEA also can be renewed or extended in the context of the permit or program providing regulatory oversight....The time frame within which a CEA remains in effect can be indeterminate, but not permanent. The only exception to this is when the GWQS [groundwater quality standards] are exceeded due to natural water quality. Since the Department will not require anyone to enhance natural water quality in an aquifer, permanent CEAs can be established in such areas.

Dredging Restrictions

Institutional controls would be established to restrict dredging or other activities that could compromise the integrity of the SRB.

4.3 Alternative 3—Containment, Excavation, and In Situ Solidification/Stabilization

Alternative 3 combines free-phase NAPL recovery using recovery wells and trenches, soil capping, soil excavation, and solidification/stabilization. Either a funnel-and-gate system or PRB would be installed to mitigate potential offsite migration of NAPL. In situ treatment of dissolved COCs in groundwater discharging to the Hudson River would be by means of an SRB. This alternative includes the maintenance of existing roads and parking surfaces. Engineering controls that would reduce the potential for vapor intrusion under future conditions are incorporated into this alternative, along with institutional controls to prevent exposures to soil or groundwater. Alternative 3 addresses principal threats identified in Section 1.10 as described below and shown in Table 4-1:

- Toxicity potential due to direct human contact with principal threat waste is addressed at NZ-1, NZ-2, and for tar boils through shallow excavation (to 4 feet bgs). Toxicity potential in the HCAA on the Quanta property and Block 93 North will be mitigated through solidification/stabilization, which sequesters COCs.
- The unoccupied basements of 115 River Road will be converted to a crawl space with new subslabs, vapor barriers, and active ventilation. Other occupied buildings will be sampled periodically and if vapor intrusion is identified, mitigation will be provided as needed.

- Toxicity potential for ecological receptors at OU2 (principal threat risk at NZ-2 and NZ-5) is reduced through the installation of a funnel-and-gate system or PRB to isolate the NAPL zones from the Hudson River.
- Mobility potential for free-phase NAPL (principal threat risk at NZ-2 and NZ-5) is reduced through NAPL recovery and a funnel-and-gate system or PRB to isolate the NAPL zones from the Hudson River.

In situ solidification/stabilization significantly reduces the potential for leaching of COCs from the low-level threat source materials in the HCAA on the former Celotex property and areas of collocated NAPL and arsenic source material.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of an SRB. Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable as described in Section 2.5; however, fate and transport evaluations presented in the final RI (CH2M HILL, 2008a) indicate that the contaminant plume is stable.

The following subsections briefly describe the components of Alternative 3.

4.3.1 Non-Aqueous Phase Liquid

Shallow NAPL in NZ-1 and NZ-2 and areas of tar boils will be excavated to a maximum depth of 4 feet bgs (Figure 4-7). Free-phase NAPL would be recovered, to the extent practicable, from recovery wells and trenches as shown in Figure 4-8. Figures 4-9, 4-10, and 4-11 depict this alternative in cross section, and Figure 4-12 shows capping and engineering controls for Alternative 3.

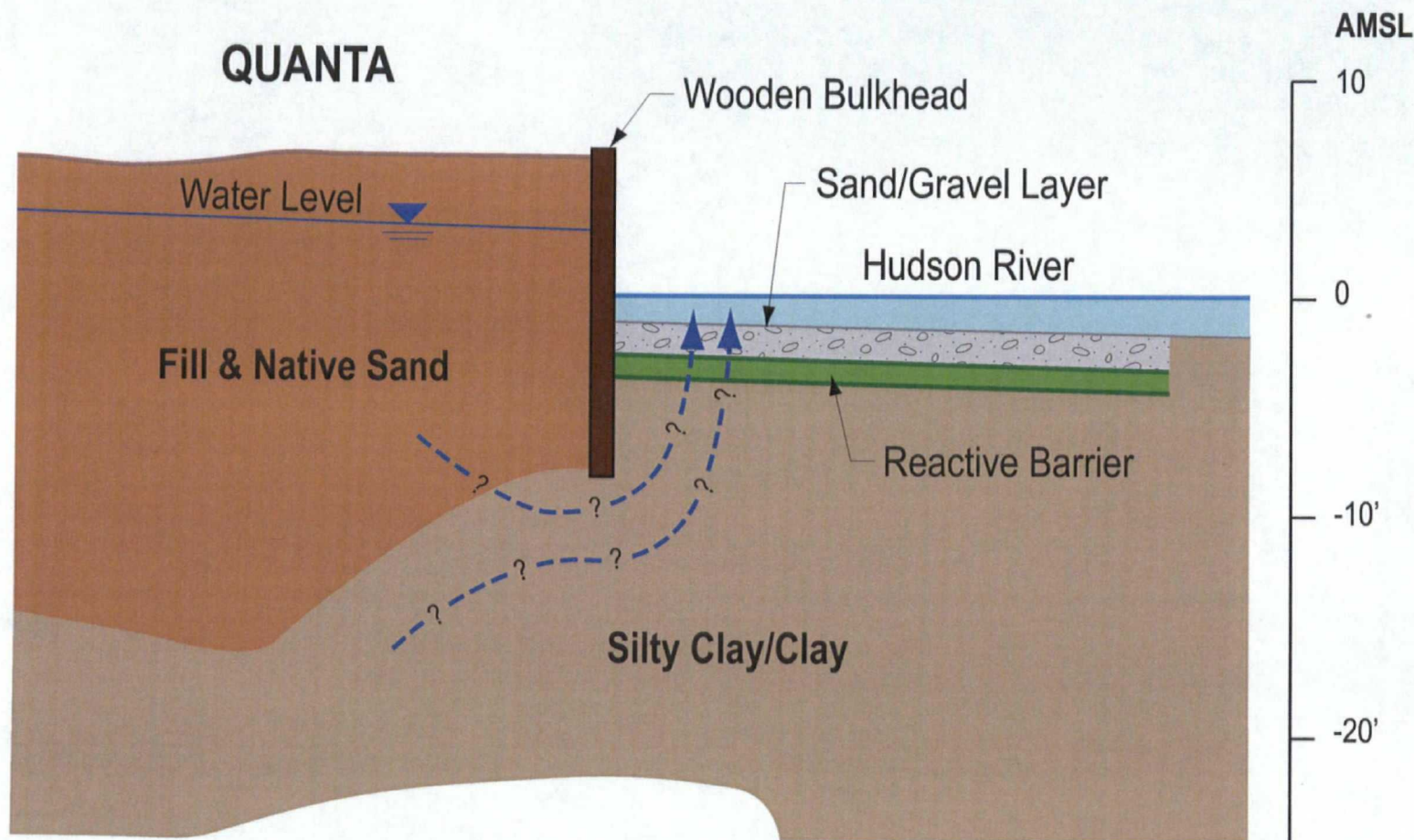
Limited Excavation of Shallow NAPL

Soil from locations at which tar boils have been observed and areas of soft, plastic, or hard tars in the vadose zone on the Quanta property will be excavated to a maximum depth of 4 feet bgs. The soils in NZ-1 and NZ-2 also have been shown to contain shallow NAPL and will be excavated to a depth of 4 feet bgs. Figure 4-8 depicts the areas to be excavated as part of this alternative.

Excavation of the shallow NAPL and tar boils will occur to 4 feet to mitigate potential risk associated with direct contact during future construction activities. The four-foot depth is based on the typical depth to groundwater at the site since excavation below the water table is complicated by the need to manage water. Potential risk associated with soils below 4 feet will be managed through institutional controls as described in Section 4.3.6. Soil underneath the 115 River Road building would not be stabilized because the exposure pathway can be addressed by engineering and institutional controls.

Details of the excavation extents, equipment to be utilized, required excavation stabilization measures, exact volumes of impacted soil to be removed, and any verification sampling would be based on predesign investigation and remedial design. Specific stormwater diversion, soil erosion controls, and air-monitoring requirements would also be assessed during remedial design. The excavation areas would be backfilled with certified clean fill





NOTES: Conceptual layout only, actual groundwater patterns will be determined during the SRI

DRAFT - FOR DISCUSSION PURPOSES ONLY

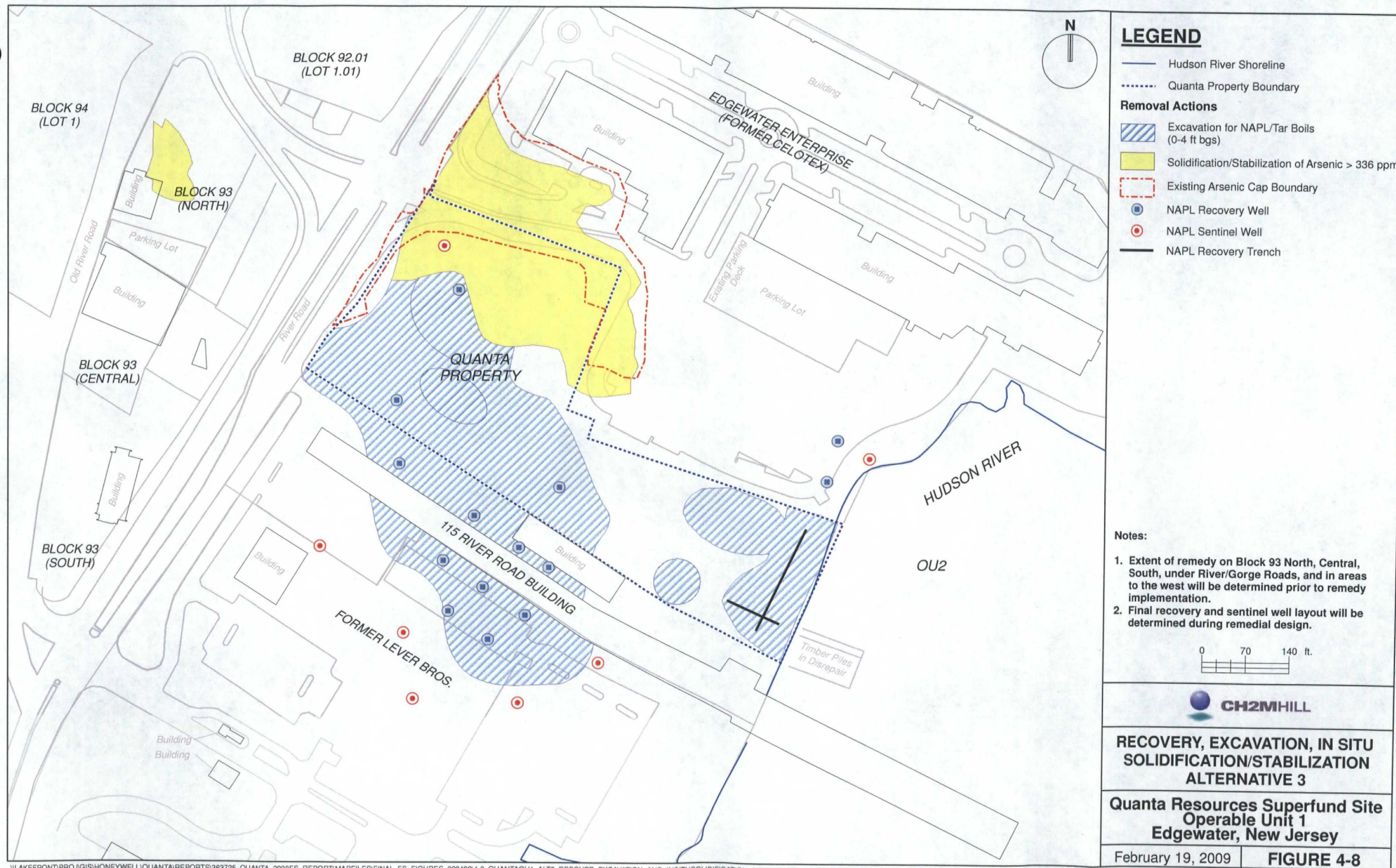


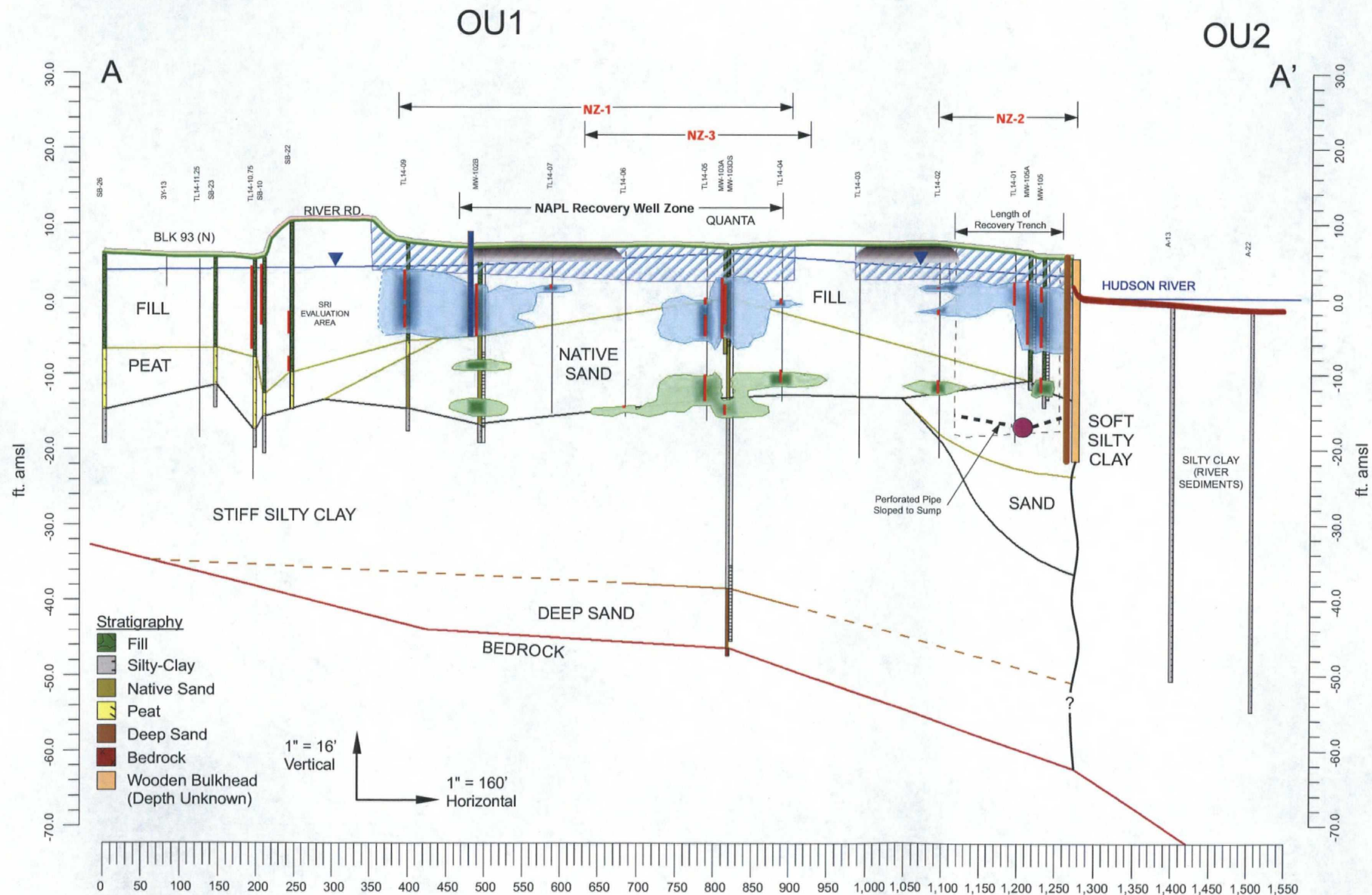
**CROSS SECTION OF
SUBAQUEOUS REACTIVE BARRIER**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

December 19, 2008

FIGURE 4-7





LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Sump
- Recovery Well
- Wooden Bulkhead (Depth Unknown)
- Engineered Cap
- Inspect/Maintain Road Surface or Foundation
- Funnel and Gate or Permeable Reactive Barrier
- Tar Boils
- Excavation
- Subaqueous Reactive Barrier

Plan view of the Quanta Resources Superfund Site

Note:

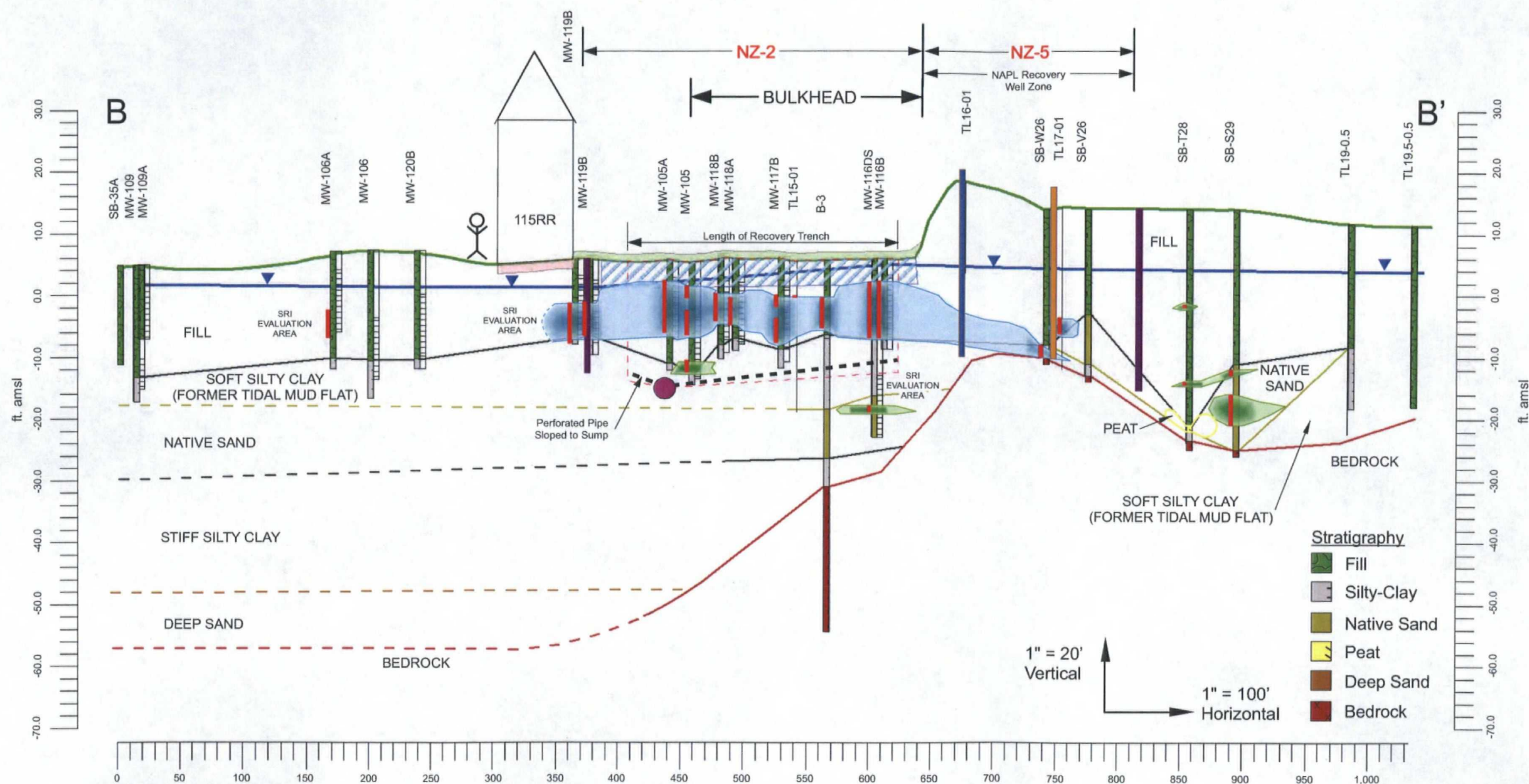
- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gratation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- Conceptual model of OU1 and OU2 boundary depicted.
- Trench shown parallel to cross-section line. Trench width will be 3-4 ft.
- ft. = feet
- amsl = above mean sea level

CH2MHILL

**ALTERNATIVE 3
CROSS-SECTION A - A'**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

December 19, 2008 **FIGURE 4-9**



LEGEND

- Interval of Observed NAPL
- Sump
- Water Table
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Excavation
- Recovery Well
- Sentinel Well
- Funnel and Gate or Permeable Reactive Barrier
- Inspect/Maintain
- Road Surface or Foundation
- Engineered Cap

Stratigraphy

- Fill
- Silty-Clay
- Native Sand
- Peat
- Deep Sand
- Bedrock

Scale: 1" = 20' Vertical, 1" = 100' Horizontal

Plan view of the Quanta Resources Superfund Site

Note:

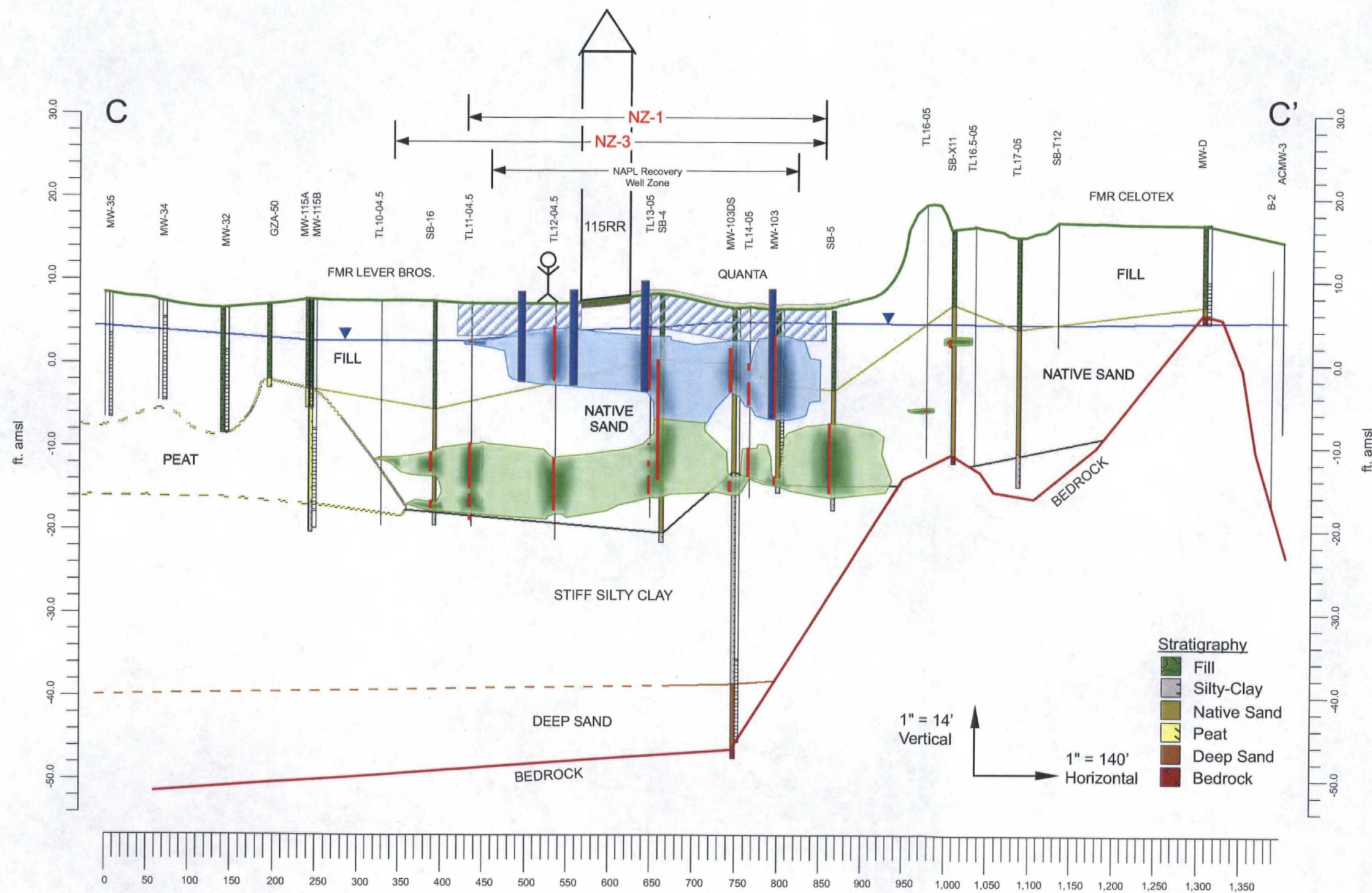
- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- Final extent of NZ-2 will be determined based on results of SRI investigation.
- ft. = feet
- amsl = above mean sea level
- Trench shown parallel to cross-section line trench width will be 3-4 ft.
- 115 River Road dimensions are estimated.

CH2MHILL

**ALTERNATIVE 3
CROSS-SECTION B - B'**

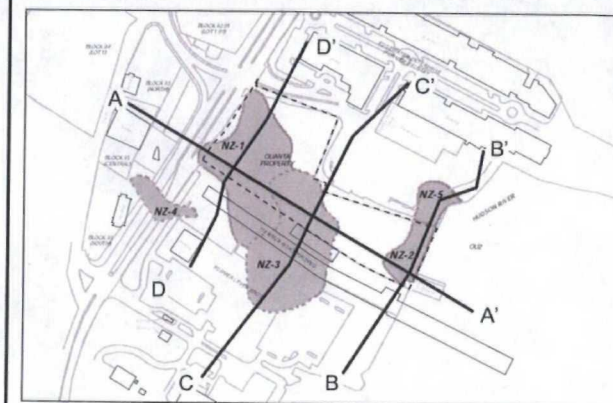
**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

December 19, 2008 **FIGURE 4-10**



LEGEND

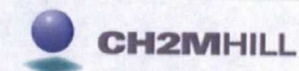
- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Excavation
- Converted Crawl Space
- Recovery Well
- Engineered Cap/Basement Slab



Plan view of the Quanta Resources Superfund Site

Notes:

- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOS (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- ft. = feet
- amsl = above mean sea level
- 115 River Road dimensions are estimated.

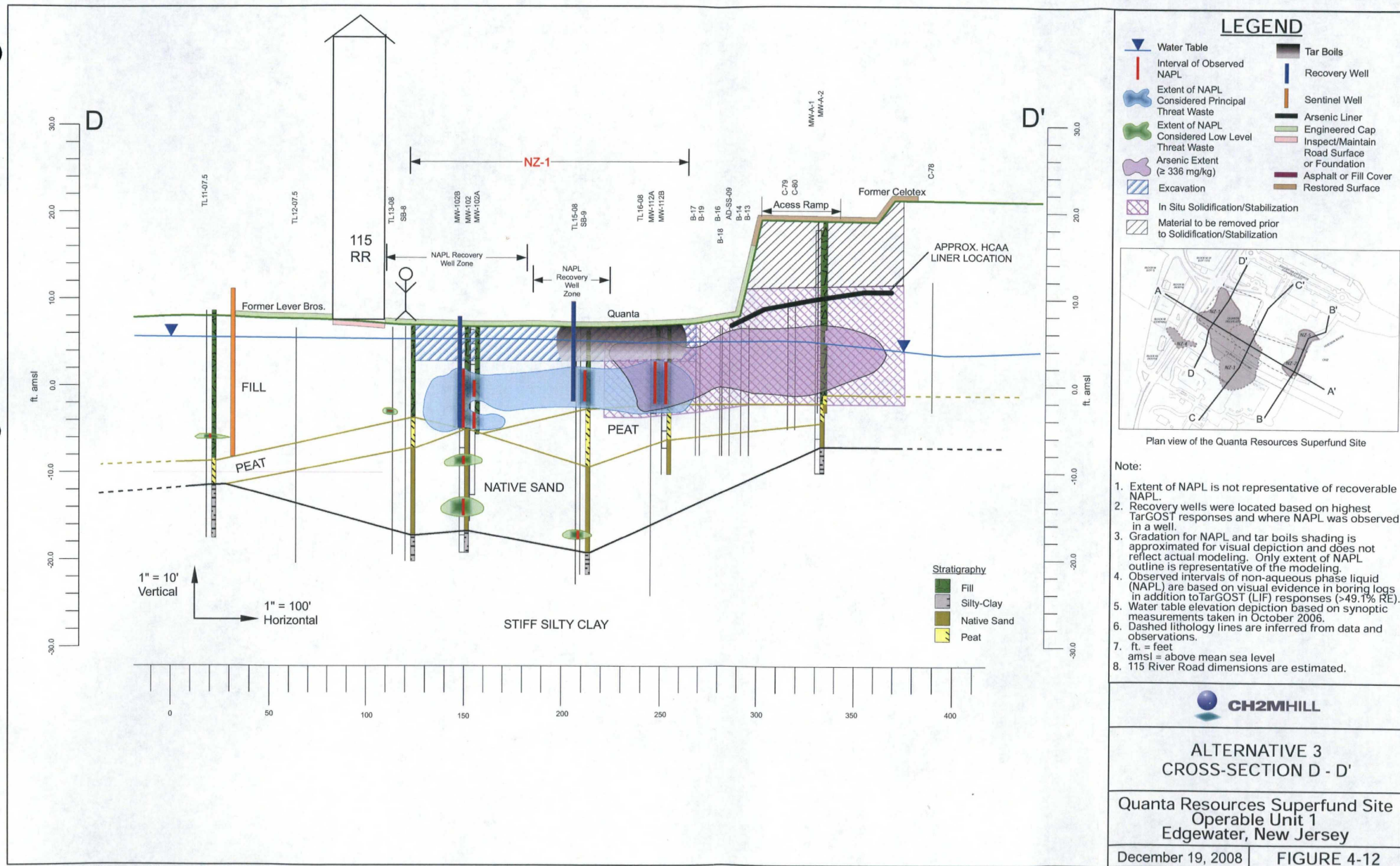


ALTERNATIVE 3 CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

FIGURE 4-11



material. The Quanta property would then be capped with a multilayer vegetative cap as described in Section 4.3.3, below.

Emission control techniques such as the use of dust suppressants and minimizing the open working area of the excavation would be employed as needed to minimize adverse effects on workers and the community from volatile emissions from soil containing NAPL. Air monitoring would be required during excavation activities.

It is anticipated that the excavated soils would not meet TCLP limits because of lead, arsenic, and/or benzene content and will need to be disposed offsite as hazardous waste. Onsite stabilization of soils will be necessary prior to disposal to meet land disposal restrictions. Soil would be stockpiled, stabilized, and then disposed of at an offsite landfill. Details of sampling requirements for excavated soils, required treatment, and disposal options would be finalized during remedial design.

Free-Phase NAPL Recovery

For purposes of this FS, the NAPL recovery system is assumed to include 14 recovery wells and two recovery trenches installed in OU1 at locations where principal threat NAPL has been identified (Figure 4-8). The exact number of recovery wells and trenches and their configuration would be finalized during the design phase of the work, should this alternative be selected. Recovery wells, trenches, and offsite disposal would be implemented as described in Section 4.2.1.

NAPL Containment

Treatment of near-shore principal threat NAPL (i.e., NZ-2 and NZ-5) potentially discharging to the river would be achieved by the installation of either a funnel-and-gate system (Figure 4-6) using sealed sheet piling and PRBs, or with a full PRB. The method of NAPL treatment would be determined during remedial design. For cost estimation purposes, this FS assumes that a funnel-and-gate system would be installed. Installation of either system on the former Celotex property may be complicated by the presence of subsurface boulders that would need to be temporarily removed.

4.3.2 Arsenic-Contaminated Soil

If Alternative 3 is implemented, soils containing arsenic in excess of 336 mg/kg would be solidified/stabilized in situ to mitigate principal threat waste on the Quanta and Block 93 North properties and to minimize leaching on the former Celotex property. Reagents designed to change the physical and chemical characteristics and the leaching potential of the material would be mixed with the soil to a depth of 10 feet bgs on the Quanta and Block 93 North properties, and to the corresponding elevation on the former Celotex property. Most reagent formulations for in situ solidification/stabilization applications consist of pozzolanic reagents, although proprietary reagents are often used in conjunction with, or instead of, pozzolanic reagents. The product of solidification/stabilization would be a monolithic mass with high strength, low permeability, and reduced leachability of COCs. Prior to implementation of solidification/stabilization at OU1, groundwater modeling would be required to evaluate the effects of the monolith on groundwater flow.

Figure 4-8 depicts the arsenic source areas to be treated with solidification/stabilization. Surface and subsurface boulders and debris greater than approximately 12 inches in

diameter interfere with the mixing process. Prior to implementation of in situ mixing, the solidification/stabilization area would be cleared of vegetation, large boulders, tank pads, and concrete, and these materials would be disposed of offsite. Deeper items of this type encountered during mixing would need to be excavated. For cost estimating purposes, offsite disposal of cleared material is assumed to be hazardous. It is assumed that temporary erosion controls would be installed and that utilities that are present in areas that are to be stabilized would be relocated.

A portion of the Quanta and former Celotex properties at which concentrations of arsenic greater than 1,000 mg/kg in soil have been detected is currently covered with a multilayer engineered cap to prevent direct contact and infiltration (Figure 4-12). The fill material above the existing cap, assumed to be approximately 10 feet deep and uncontaminated, would be removed before soil mixing and set aside for reuse at the Site. The actual amount of fill material that can be removed would be determined based on an evaluation of the stability of the adjacent structures and would be finalized during remedial design. It is assumed for the purposes of the FS that approximately 75 percent of the fill material in the solidification/stabilization area could be removed to the depth of the liner (10 feet bgs) and that 25 percent of the fill material closest to the building could be removed to a depth of 4 feet bgs.

Solidification/stabilization adjacent to structures (i.e., buildings and roads) would require a stability analysis to determine the precautions and protective measures required to ensure that structural integrity is not compromised during implementation. Depending on the results of the stability analysis, access to the HCAA on the former Celotex property for treatment may be limited due to the existing building.

Large-diameter (6 feet or greater) augers would be advanced through the targeted soils. Upon reaching the target depths, reagents would be injected through the augers to treat the material that is located between the ground surface and the target depth. The augers would be advanced and retracted through the treatment area several times in an overlapping pattern to provide for complete mixing. The selection of mixing equipment would be determined during final design. Auger diameter would depend on depth of drilling, consistency and hardness of soil, and soil porosity. Vapor suppressant foam and black plastic or similar materials would be used for dust and vapor management along with noise reduction coverings to protect workers and the community during construction activities.

Prior to implementation of the soil mixing, bench scale testing would be required to

- Develop and optimize a reagent formulation (reagent(s) and their concentrations) that would achieve the cleanup goals in the area of the arsenic-contaminated soils and the soil areas where arsenic and NAPL are collocated.
- Determine the amount of expansion that would occur (i.e., increase in volume from added material and swelling)
- Evaluate physical properties of the soil following solidification/stabilization
- Determine how the chemical reaction for stabilizing the arsenic would impact NAPL mobility

- Evaluate possible interactions between reagents used for ISCO in the NAPL zones and stabilization in the HCAA (i.e., interactions that may occur in areas where NAPL and arsenic are collocated)
- Evaluate potential impacts that solidification/stabilization and the selected reagent(s) could have on the adjacent structures

Following the completion of the bench-scale tests, the successful mix batches will be tested onsite in a pilot-scale test. The pilot test plan will include procedures for determining success of full-scale solidification/stabilization, including evaluation of the potential implementation challenges and costs that could result from debris and concrete encountered.

For costing purposes, it is assumed that 15 percent cement by weight and 5 percent ferrous sulfate by weight (used to precipitate the arsenic as insoluble ferric arsenate) would be used to solidify and stabilize the target soils in situ, and that the soils would expand 25 percent.

During implementation of the full-scale remedial action, testing would be performed for the purpose of mix optimization, quality assurance, and verification that the remedy is effective. Verification sampling details would be developed during remedial design, and may include tests of compressive strength, permeability, and leachability.

Residents and tenants on the former Celotex property will need to have temporary relocation of access and entrances during remediation and construction activities. The access ramp to the property will have to be rerouted during arsenic stabilization.

Upon completion of the solidification/stabilization activities, the stabilized area of the Quanta property would be graded and covered with either asphalt or soil and vegetative cover. For costing purposes it is assumed soil and vegetative cover will be used. On the former Celotex property, the stabilized area will be restored to the previous condition (e.g., parking lot or roadway). The stabilized area on Block 93 North would be graded and returned to use as a parking lot.

4.3.3 Residual Soil

Areas where site-related constituents exceed PRGs in shallow soil would be capped with an engineered cap to prevent direct contact and to minimize erosion by controlling surface water runoff. The cap would be placed over the Quanta property and the remaining remedial areas on the 115 River Road, Block 93 North, Block 93 Central, and Block 93 South properties, replacing existing asphalt or other material with the engineered cap (Figure 4-13). Caps are assumed to be comprised of materials as described in Section 4.2.3 for Alternative 2.

4.3.4 Vapor

The basements of the 115 River Road building would be upgraded with engineered subslabs and converted to actively ventilated crawl spaces as described in Section 4.2.4.

Vapor intrusion mitigation measures would be installed and maintained in other occupied buildings, if needed, as determined by periodic indoor air sampling or other vapor intrusion evaluations.

4.3.5 Groundwater

Groundwater that discharges in the Hudson River, or OU2, would be treated by an SRB and monitored as described in Section 4.2.5.

4.3.6 Institutional Controls

Land Use Restrictions

Alternative 3 reduces exposure to impacted media left in place through engineered caps, NAPL recovery, shallow excavation of NAPL-contaminated soil solidification/stabilization of arsenic, and institutional controls. Institutional controls would consist of land use restrictions for all areas at which COCs remain in place in soil or groundwater in exceedance of PRGs, as described in Section 4.2.6.

Groundwater Use Restrictions

Groundwater use restrictions in the form of a CEA would be implemented as described in Section 4.2.6 and would remain in place until COC concentrations are below PRGs.

Dredging Restrictions

Institutional controls would be established to restrict dredging or other activities that could compromise the integrity of the SRB.

4.4 Alternative 4—In Situ Solidification/Stabilization

The primary component of Alternative 4 is the in situ solidification/stabilization of principal threat waste, including NAPL and arsenic. In situ treatment of dissolved COCs in groundwater discharging to the Hudson River would be by means of an SRB. This alternative includes the maintenance of existing roads and parking surfaces. Engineering controls that would reduce the potential for vapor intrusion under future conditions are incorporated into this alternative, along with institutional controls to prevent exposures to soil or groundwater.

Alternative 4 addresses principal threats identified in Section 1.10 as described below and shown in Table 4-1:

- Direct contact with principal threat waste at NZ-1, NZ-2, the tar boils, and the HCAA on the Quanta property and Block 93 North is mitigated in situ through the sequestration of COCs within a solidified/stabilized mass.
- The unoccupied basements of 115 River Road will be converted to a crawl space with new subslabs, vapor barriers, and active ventilation. Other occupied buildings will be sampled periodically and if vapor intrusion is identified, mitigation will be provided as needed.
- Mobility potential for free-phase NAPL (principal threat waste at NZ-2 and NZ-5) and toxicity potential for ecological receptors at OU2 is reduced through solidification/stabilization, which restricts leaching and migration.

In situ solidification/stabilization significantly reduces the potential for leaching of COCs from the low-level threat source materials in the HCAA on the former Celotex property and areas of collocated NAPL and arsenic source material.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of an SRB. Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable as described in Section 2.5; however, fate and transport evaluations presented in the final RI (CH2M HILL, 2008a) indicate that the contaminant plume is stable.

The following subsections briefly describe the components of Alternative 4.

4.4.1 Non-Aqueous Phase Liquid

Principal threat NAPL (present at NZ-1, NZ-2, NZ-5, and the tar boils) would be solidified/stabilized in situ. Figure 4-14 depicts the NAPL areas to be treated with solidification/stabilization as part of this alternative. In situ solidification/stabilization is a straightforward technology that would reduce the toxicity and mobility of principal threat waste. This method sequesters COCs to reduce the potential for NAPL mobility and leaching to groundwater. Figures 4-15 through 4-18 depict in cross-section view the NAPL mitigation measures associated with this alternative. Soil underneath the 115 River Road building would not be stabilized because the exposure pathway can be addressed via other means, such as engineering controls.

Prior to implementation of in situ mixing, the solidification/stabilization area would be cleared of vegetation, large boulders, tank pads, and concrete, and these materials would be disposed of offsite. Deeper items of this type encountered during mixing would need to be excavated because boulders and debris greater than approximately 12 inches in diameter interfere with the mixing process.

Based on field experience at this site and preliminary geophysical evaluation, a number of subsurface structures would also have to be removed (such as concrete slabs and pads, buried metal, and buried wooden structures) prior to solidification/stabilization implementation. Within the area of NZ-2, additional geophysical investigation is being performed as part of the SRI to evaluate the dimensions and characteristics of the known wooden bulkhead and possible landward bulkheads or former shoreline features. Depending on the findings of the geophysical survey, alternative methods for implementation may be used to achieve the solidification/stabilization of NZ-2. The clean fill material present on top of NZ-5 does not need to be stabilized and will be temporarily removed prior to remediation.

For cost-estimating purposes, offsite disposal of cleared material is assumed to be hazardous. It is assumed that temporary erosion controls would be installed and that utilities that are present in areas that are to be stabilized would be abandoned and relocated.

Solidification/stabilization adjacent to structures (i.e., buildings and roads) would require a stability analysis to determine the precautions and protective measures required to ensure that structural integrity is not compromised during implementation. The results of the

stability analysis will determine the distance required to be maintained between the treatment zone and the existing buildings (i.e., 115 River Road).

Solidification/stabilization will be implemented from the shoreline moving inland, so that equipment remains on unsolidified material. Engineering controls may be required to address the potential for NAPL migration during implementation.

Large-diameter (6 feet or greater) augers would be advanced to the following target depths below ground surface, based on NAPL zone characterization and principal threat criteria: NZ-1 to 11 feet, NZ-2 to 14 feet, and NZ-5 to 25 feet. Upon reaching the target depths, reagents would be injected through the augers to treat the material that is located between the ground surface and the target depth. The augers would be advanced and retracted through the treatment area several times in an overlapping pattern to provide for complete mixing. The selection of mixing equipment would be determined during final design. Auger diameter would depend on depth of drilling, consistency and hardness of soil, and soil porosity. Vapor suppressant foam and black plastic or similar materials would be used for dust and vapor management along with noise reduction coverings to protect workers and the community during construction activities.

Prior to implementation of the soil mixing, bench scale testing would be required to

- Develop and optimize a reagent formulation (reagent(s) and concentrations) that would achieve the cleanup goals
- Determine the amount of expansion that would occur (i.e., increase in volume from added material and swelling)
- Evaluate physical properties of the soil following solidification/stabilization
- Evaluate potential impacts that solidification/stabilization and the selected reagent(s) could have on the adjacent structures

Following the completion of the bench-scale tests, the mix batches that successfully achieve key performance parameters (e.g., unconfined compressive strength, permeability, and leachability) will be tested onsite in a pilot-scale test. Key reasons for conducting the pilot test would be to (1) determine the optimal reagent mix, (2) confirm corresponding cost-effectiveness under full-scale conditions, and (3) confirm compatibility with redevelopment objectives. A pilot test will be developed that include procedures for determining the success of full-scale solidification/stabilization and for evaluating the potential implementation challenges and costs that could result from debris and concrete encountered.

For costing purposes, it was assumed that 15 percent cement by weight would be used to solidify/stabilize the NAPL soils in place and the treated soils would expand by 25 percent. During implementation of the full-scale remedial action, testing would be performed for the purpose of mix optimization, quality assurance, and verification that the remedy is effective. Verification sampling details would be developed during remedial design, and may include tests of compressive strength, permeability, and leachability.

Source material that is located outside the solidification/stabilization area on the Quanta property would be addressed as described below. The solidification/stabilization areas on



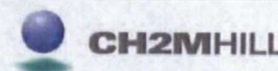
LEGEND

- Hudson River Shoreline
- - - - - Quanta Property Boundary
- Capping / Engineering Controls**
 - New Engineered Cap
 - New Basement Slab (Converted to Crawl Space)
 - Inspect/maintain existing road surface or slab-on grade foundation
 - Restored Surface

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Cutoff wall implemented if necessary for redevelopment prior to OU2 decision.
3. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
4. Required extent of new engineered cap as shown; final extent to be determined during remedial design.
5. Surface soils south of 115 River Road will be addressed with redevelopment of former Lever Bros. property.
6. Disturbed surfaces will be restored to previous conditions after remediation.

0 70 140 ft.



CAPPING/ENGINEERING CONTROLS - ALTERNATIVE 3

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE 4-13



LEGEND

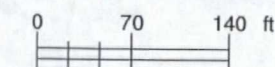
- Hudson River Shoreline
- Quanta Property Boundary
- - - Existing Arsenic Cap Boundary

In Situ Solidification/Stabilization Treatment

- Solidification/Stabilization of Arsenic > 336 mg/kg
- Solidification/Stabilization of NAPL

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Cutoff wall implemented if necessary for redevelopment prior to OU2 decision.
3. Temporary access to Former Celotex property may be requested during stabilization activities.

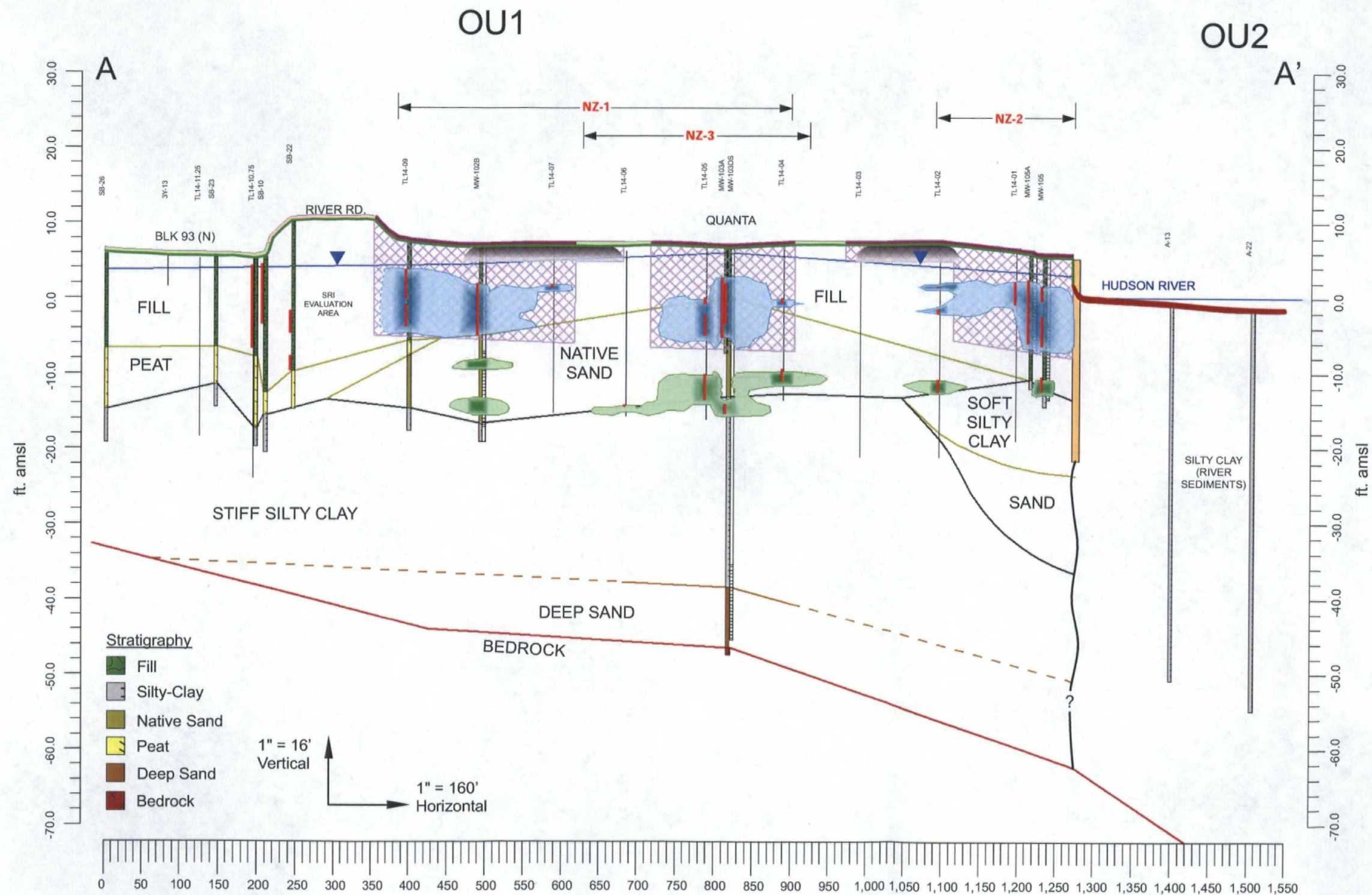


IN SITU SOLIDIFICATION / STABILIZATION - ALTERNATIVE 4

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE 4-14

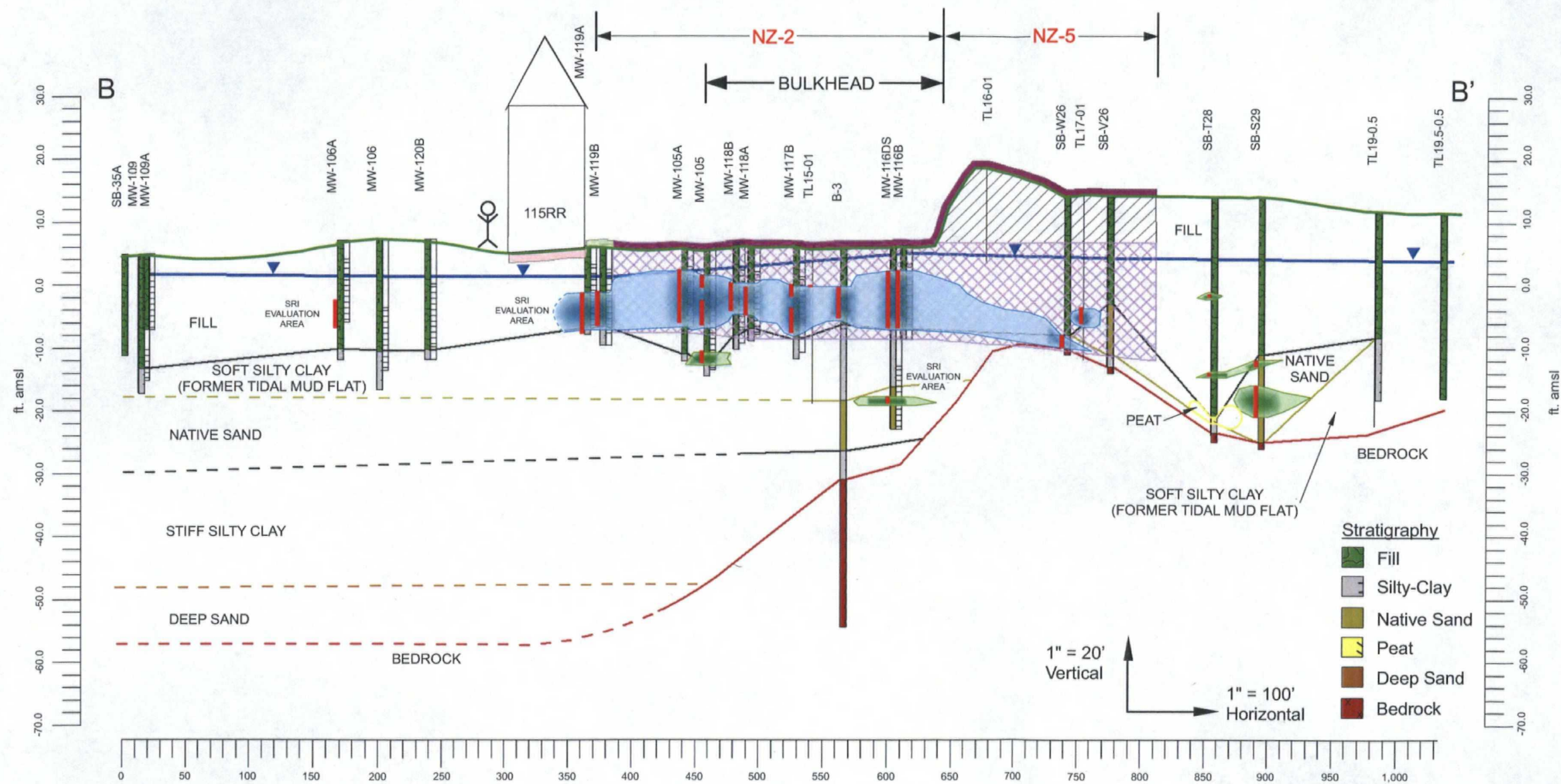


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**ALTERNATIVE 4
CROSS-SECTION A - A'**

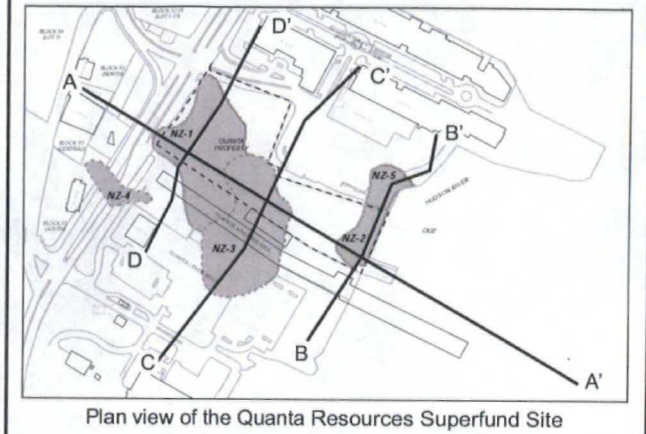
**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

December 19, 2008 **FIGURE 4-15**



LEGEND

Water Table	Inspect/Maintain Road Surface or Foundation
Interval of Observed NAPL	In Situ Solidification/Stabilization
Extent of NAPL Considered Principal Threat Waste	Material to be Removed Prior to Solidification/Stabilization
Extent of NAPL Considered Low Level Threat Waste	Asphalt or Fill Cover
Engineered Cap	



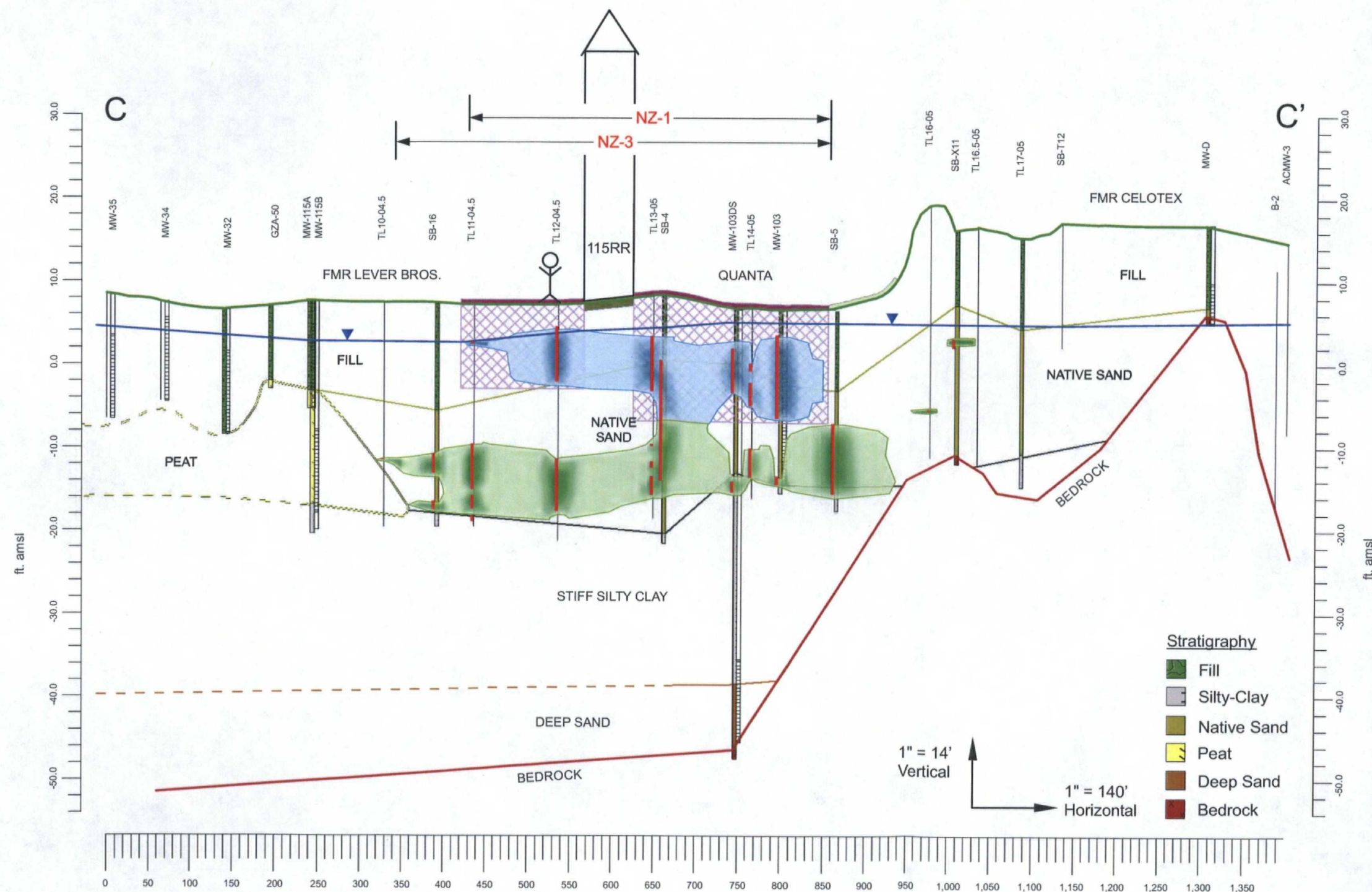
- Note:**
1. Extent of NAPL is not representative of recoverable NAPL.
 2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
 3. Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
 4. Water table elevation depiction based on synoptic measurements taken in October 2006.
 5. Dashed lithology lines are inferred from data and observations.
 6. Final extent of NZ-2 will be determined based on results of SRI investigation.
 7. ft. = feet
amsl = above mean sea level
 8. 115 River Road dimensions are estimated.

CH2MHILL

ALTERNATIVE 4
CROSS-SECTION B - B'

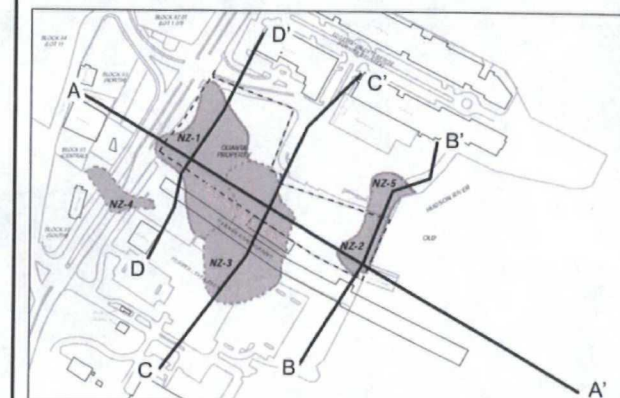
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008
FIGURE 4-16



LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Engineered Cap
- Converted Crawl Space
- In Situ Solidification/Stabilization
- Asphalt or Fill Cover



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
4. Water table elevation depiction based on synoptic measurements taken in October 2006.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
amsl = above mean sea level
7. 115 River Road dimensions are estimated.

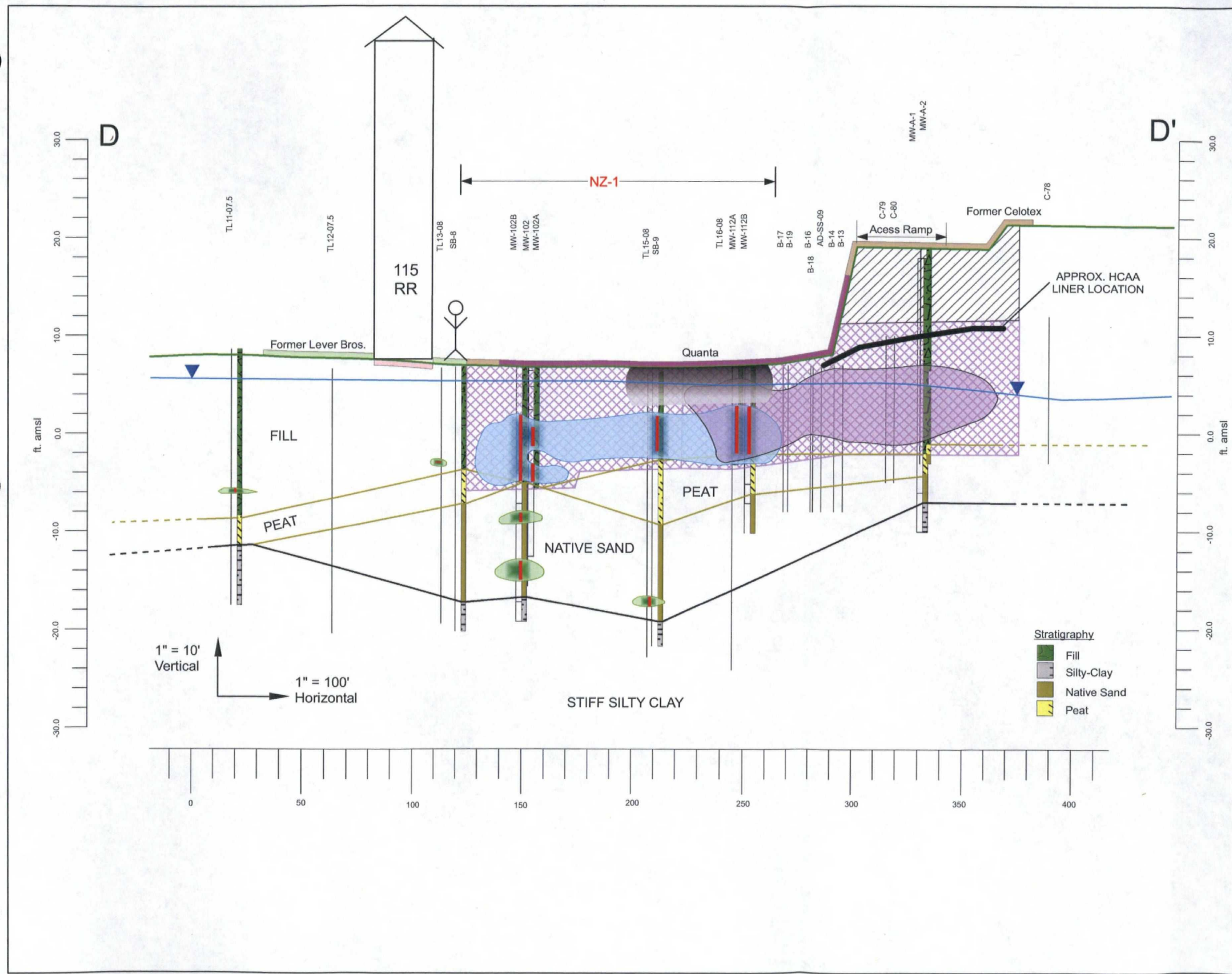


ALTERNATIVE 4 CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

FIGURE 4-17



LEGEND

Water Table	Interval of Observed NAPL	Extent of NAPL Considered Principal Threat Waste	Extent of NAPL Considered Low Level Threat Waste	Arsenic Extent (≥ 336 mg/kg)	In Situ Solidification/Stabilization	Material to be removed prior to Solidification/Stabilization	Tar Boils	Arsenic Liner	Engineered Cap	Inspect/Maintain Road Surface or Foundation	Asphalt or Fill Cover	Restored Surface
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Plan view of the Quanta Resources Superfund Site

Note:

- Extent of NAPL is not representative of recoverable NAPL.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs in addition to TarGOST (LIF) responses ($>49.1\%$ RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- ft. = feet
- amsl = above mean sea level
- 115 River Road dimensions are estimated.

CH2MHILL

**ALTERNATIVE 4
CROSS-SECTION D - D'**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

December 19, 2008 **FIGURE 4-18**

the former Celotex property (NZ-5) and 115 River Road (portion of NZ-1) would be graded and restored to their previous conditions (parking lots). On the Quanta property, stabilized areas would be covered with either fill material or asphalt.

4.4.2 Arsenic-Contaminated Soil

Soil areas containing arsenic in excess of 336 mg/kg would be solidified/stabilized in situ, as described in Section 4.3.2, to mitigate principal threat potential risk on the Quanta and Block 93 North properties and to minimize leaching on the former Celotex property. Figure 4-14 depicts the areas to be treated with solidification/stabilization as part of Alternative 4.

4.4.3 Residual Soil

Areas within which site-related constituents exceed PRGs in shallow soil would be capped with an engineered cap, eliminating the direct contact exposure pathway for this medium and minimizing. The cap would be placed over the Quanta property and the remaining outdoor remedial areas on the 115 River Road, Block 93 North, Block 93 Central, and Block 93 South properties, replacing existing asphalt or other material with the engineered cap (Figure 4-19). Caps are assumed to be comprised of materials as described in Section 4.2.3 for Alternative 2.

4.4.4 Vapor

The basements of the 115 River Road building would be upgraded with engineered subslabs and converted to actively ventilated crawl spaces, as described in Section 4.2.4.

Vapor intrusion mitigation measures would be installed and maintained in other occupied buildings, if needed, as determined by periodic indoor air sampling or other vapor intrusion evaluations.

4.4.5 Groundwater

Groundwater that discharges in the Hudson River, or OU2, would be treated by an SRB as described in Section 4.2.5 and preliminarily depicted in Figure 4-20.

Details of the groundwater monitoring frequency and post-remediation monitoring network (number of wells, sampling locations, constituent analysis list) will depend on the final remedial design. Once implementation of the remedy has begun, the monitoring network would be periodically reevaluated. Cost estimating assumptions made including the monitoring network and sampling frequency and analytes are included in Appendix C.

4.4.6 Institutional Controls

Dredging Restrictions

Institutional controls would be established to restrict dredging or other activities that could compromise the integrity of the SRB.

Land Use Restrictions

Alternative 4 would reduce exposure to impacted media left in place through the use of engineered caps, solidification/stabilization of NAPL and arsenic, and institutional controls.

4.5.1 Non-Aqueous Phase Liquid

Shallow NAPL present in NZ-1, NZ-2, and the tar boils would be excavated to a depth of 4 feet bgs. Free-phase NAPL would be recovered, to the extent practicable, from recovery wells and trenches. The approximate location of excavations, NAPL recovery wells, and NAPL recovery trenches are depicted in Figure 4-21. Figures 4-23 through 4-26 depict in cross-section view the NAPL mitigation measures associated with this alternative.

Free-Phase NAPL Recovery

For purposes of this FS, the NAPL recovery system is assumed to include 14 recovery wells and two recovery trenches installed in OU1 at locations where principal threat NAPL has been identified (Figure 4-8). The exact number of recovery wells and trenches and their configuration would be finalized during the design phase of the work, should this alternative be selected. Recovery wells, trenches, and offsite disposal would be implemented as described in Section 4.2.1.

Limited Excavation of Shallow NAPL

Soil from locations at which tar boils have been observed and areas of soft, plastic, or hard tars in the vadose zone on the Quanta property would be excavated to a maximum depth of 4 feet bgs. In addition, the soils in NZ-1 and NZ-2, which have been shown to contain shallow NAPL, would be excavated to a depth of 4 feet bgs. Soil underneath the 115 River Road building would not be excavated because the exposure pathway can be addressed via institutional and engineering controls. Figure 4-21 depicts the areas to be excavated as part of this alternative. Excavation would be conducted as described in Section 4.3.1.

In Situ Chemical Treatment

While there are several options available for treating residual NAPL in place, for purposes of this FS the use of ISCO has been assumed as the in situ treatment option. ISCO has been used at coal tar sites and it provides a useful analog for other in situ treatment options. ISCO involves the addition of chemical oxidants, such as Fenton's reagent (hydrogen peroxide plus ferrous sulfate), to chemically oxidize organic COCs to carbon dioxide and water. The reagent would be injected through boreholes on a grid of locations throughout the NZ-1, NZ-2, and NZ-5 areas (Figure 4-24). The oxidant would also be injected at varying depth intervals based on the location of NAPL in the subsurface. Application of ISCO may be complicated or, in some areas, prevented by the presence of boulders or other subsurface obstructions, particularly on the Quanta and former Celotex properties.

A bench-scale treatability test using both Fenton's reagent and sodium persulfate was conducted by Geo-Cleanse® International, Inc. (Kenilworth, N.J.) on site-specific media to

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO



LEGEND

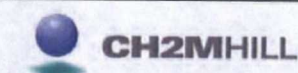
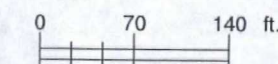
- Hudson River Shoreline
- Quanta Property Boundary

Capping/Engineering Controls:

- Inspect/maintain existing road surface or slab-on grade foundation
- New Engineered Cap
- New Basement Slab (Converted to Crawl Space)
- Asphalt or Fill Cover
- Restored Surface

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Disturbed surfaces will be restored to previous conditions after remediation.
3. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
4. Surface soils south of 115 River Road will be addressed with redevelopment of former Lever Bros. property.

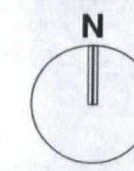
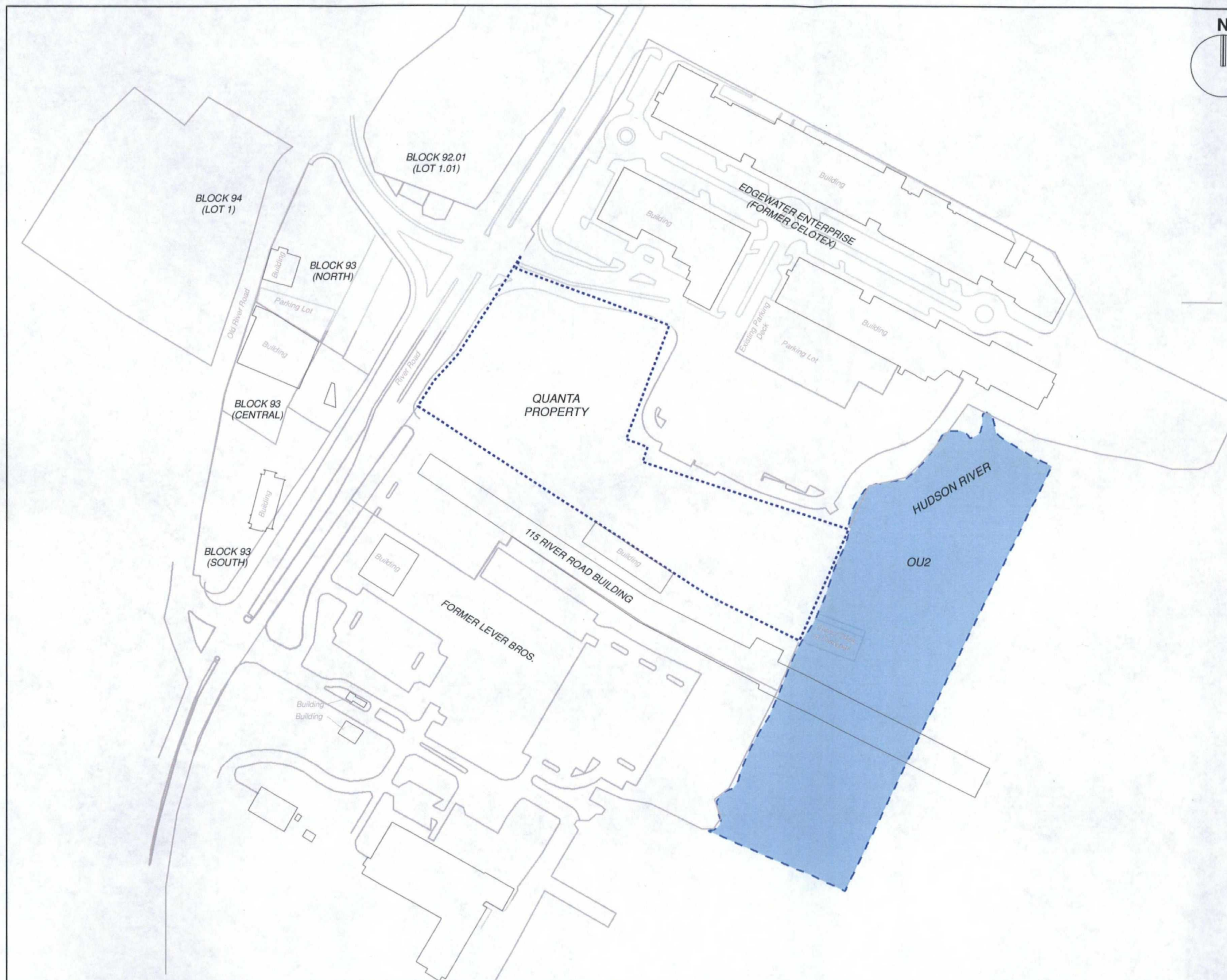


CAPPING/ENGINEERING CONTROLS - ALTERNATIVE 4

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

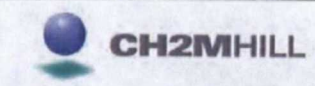
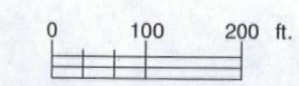
February 19, 2009

FIGURE 4-19



LEGEND

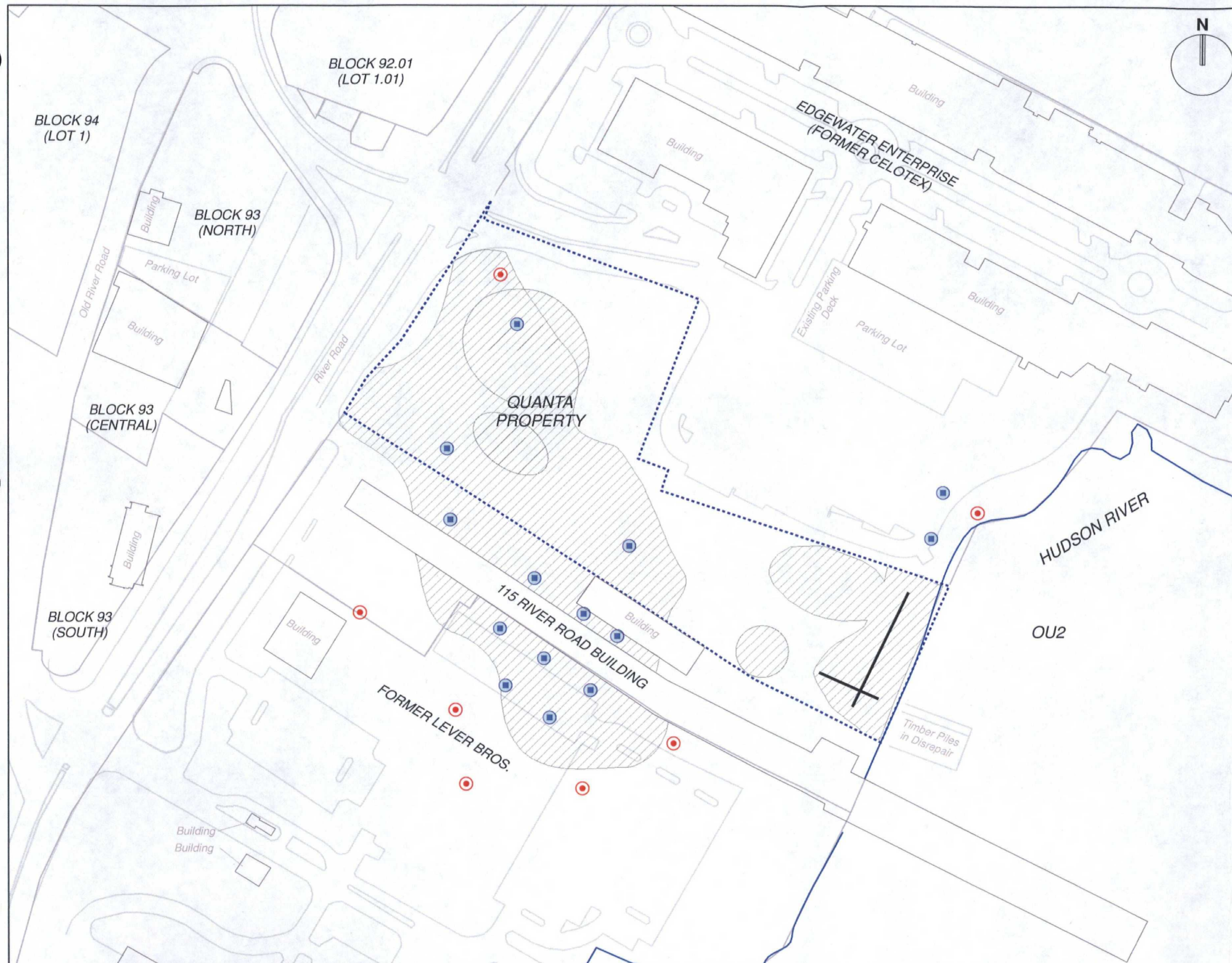
- Quanta Property Boundary
- Extent of Subaqueous Reactive Barrier



**CONCEPTUAL EXTENT OF
SUBAQUEOUS REACTIVE BARRIER
ALTERNATIVES 4,5, AND 6**

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

February 19, 2009 **FIGURE 4-20**



LEGEND

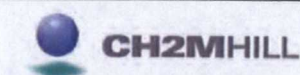
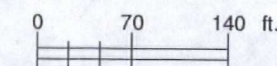
- Hudson River Shoreline
- Quanta Property Boundary

Removal Actions:

- Excavation for NAPL/Tar Boils (0 - 4 ft bgs)
- NAPL Recovery Well
- NAPL Sentinel Well
- NAPL Recovery Trench

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Final recovery and sentinel well layout will be determined during remedial design.

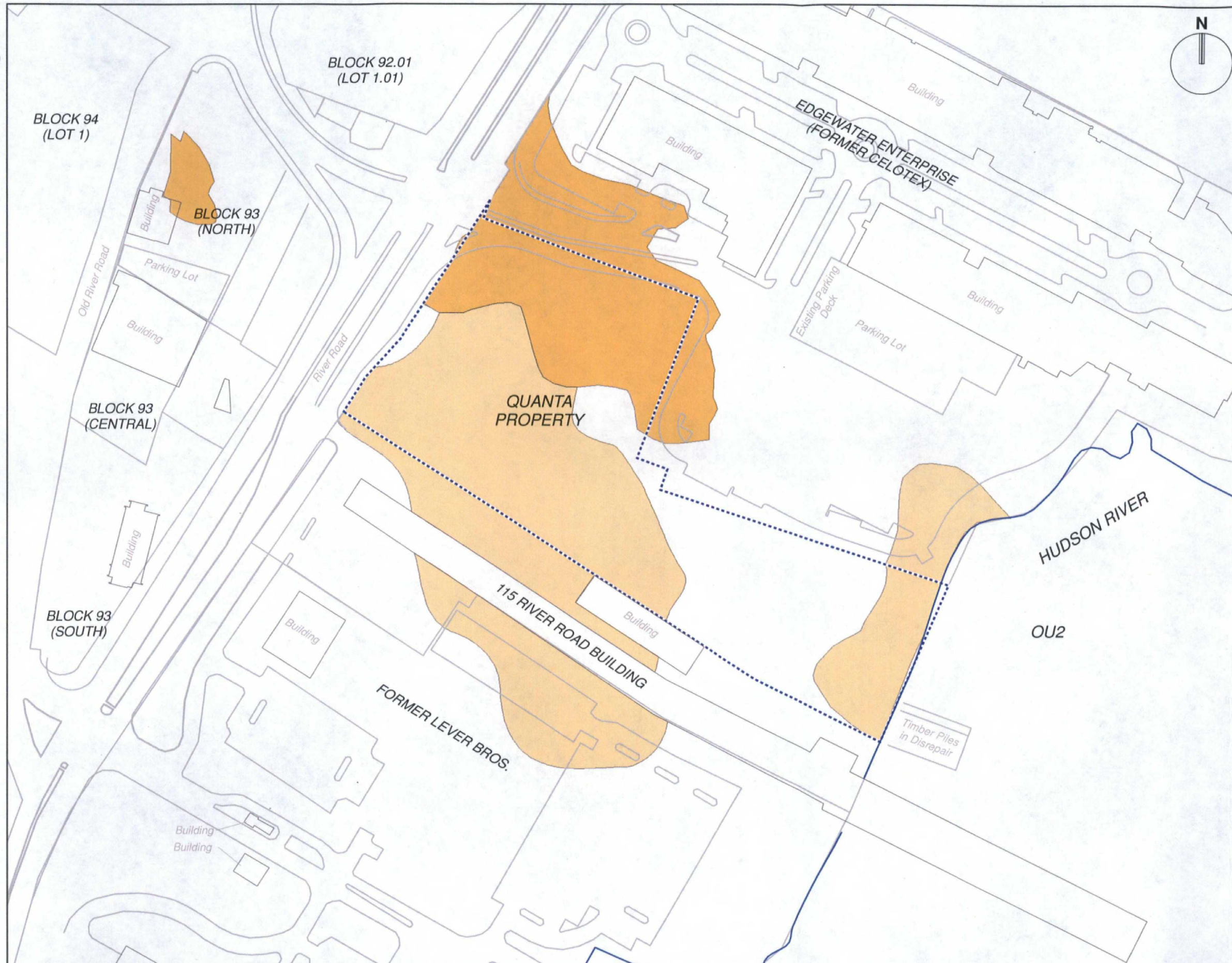


EXCAVATION AND NAPL RECOVERY - ALTERNATIVE 5

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE 4-21

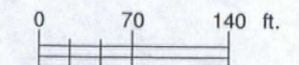


LEGEND

- Hudson River Shoreline
- - - - Quanta Property Boundary
- ISCO
- Solidification/Stabilization for Arsenic > 336 mg/kg

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.

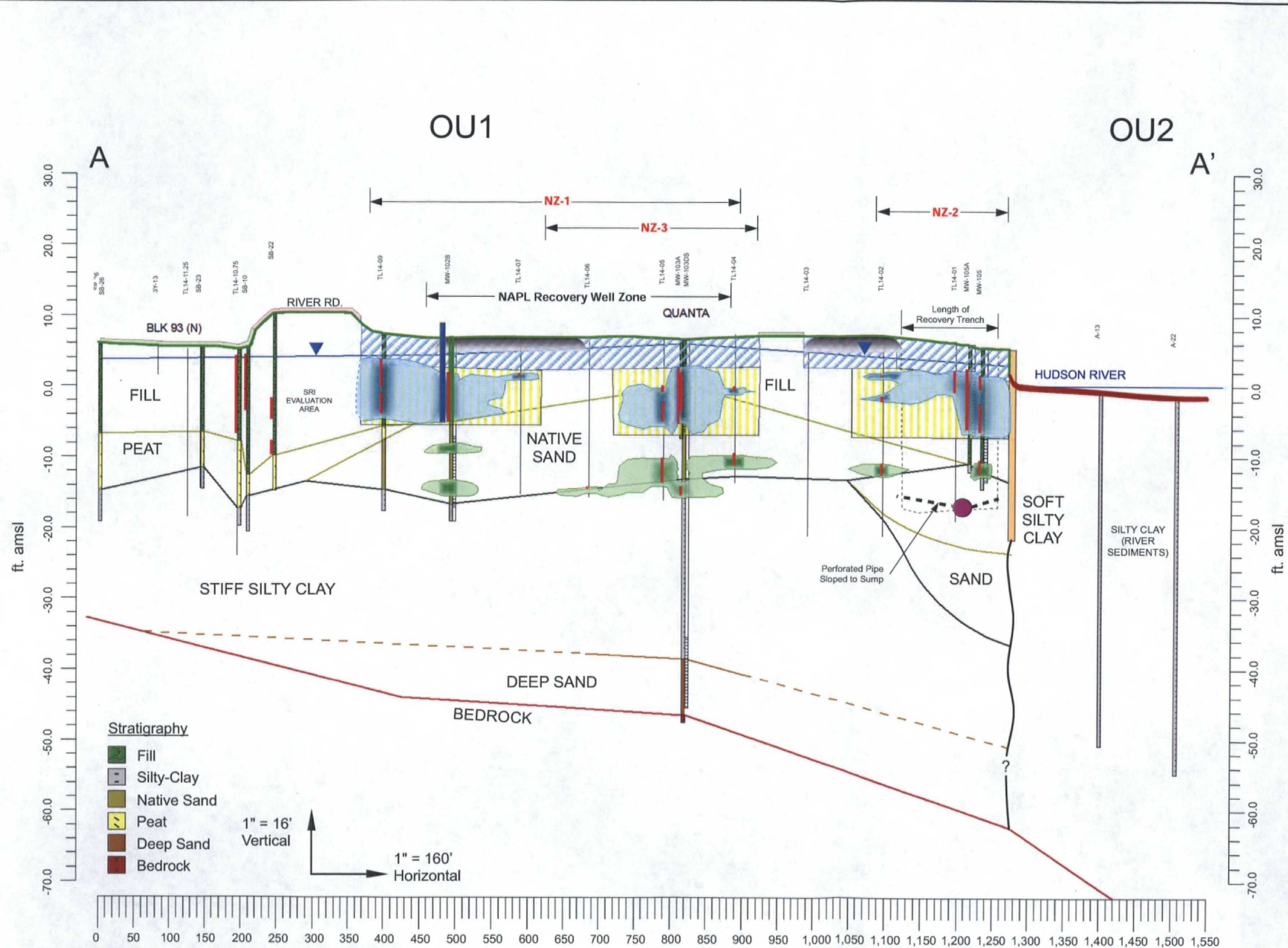


IN SITU SOLIDIFICATION/STABILIZATION AND OTHER INSITU TREATMENT ALTERNATIVE 5

**Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey**

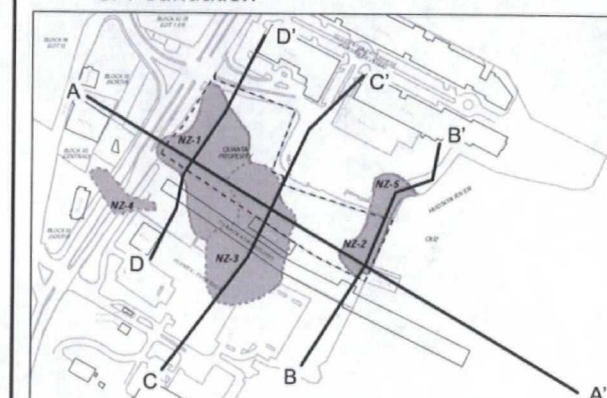
February 19, 2009

FIGURE 4-22



LEGEND

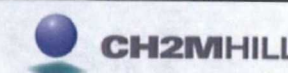
- Sump
- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Inspect/Maintain Road Surface or Foundation
- Excavation
- ISCO Treatment
- Recovery Well
- Engineered Cap
- Tar Boils
- Wooden Bulkhead (Depth Unknown)
- Subaqueous Reactive Barrier



Plan view of the Quanta Resources Superfund Site

Note:

- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gratation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- Conceptual model of OU1 and OU2 boundary depicted.
- Trench shown parallel to cross-section line. Trench width will be 3-4 ft.
- ft. = feet
amsl = above mean sea level

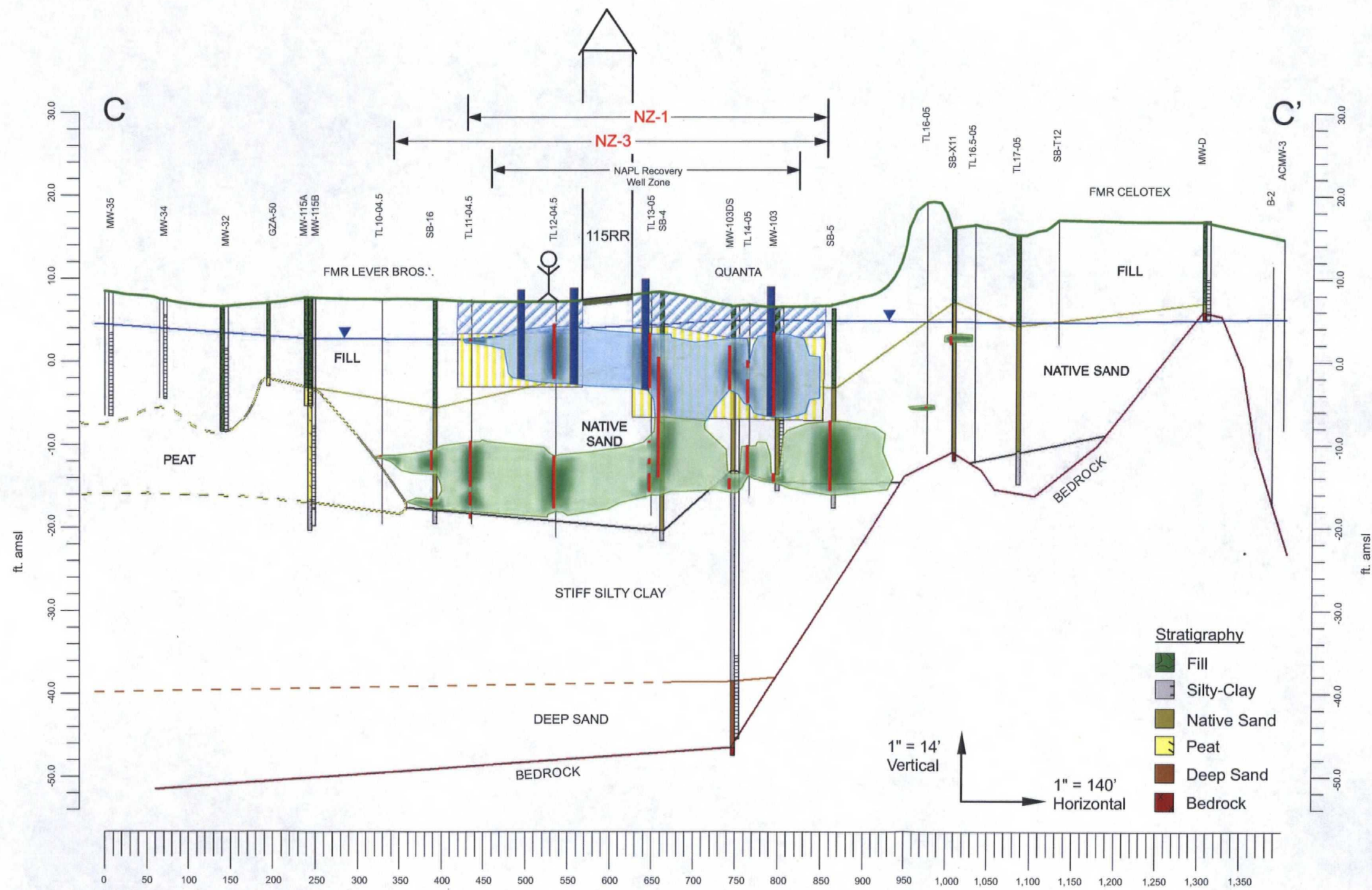


ALTERNATIVE 5 CROSS-SECTION A - A'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

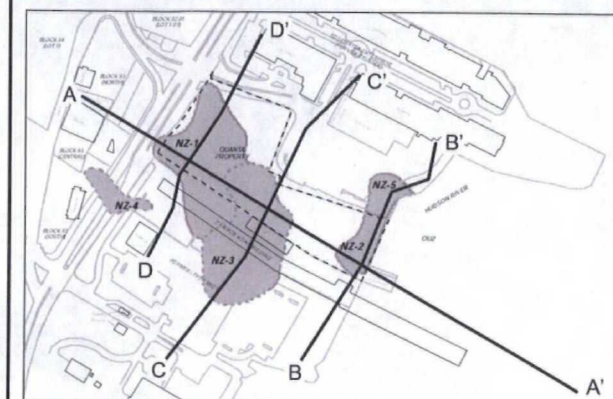
December 19, 2008

FIGURE 4-23



LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Excavation
- ISCO Treatment
- Recovery Well
- Converted Crawl Space



Plan view of the Quanta Resources Superfund Site

Notes:

- Extent of NAPL is not representative of recoverable NAPL.
- Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of NAPL are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- ft. = feet
amsl = above mean sea level
- 115 River Road dimensions are estimated.

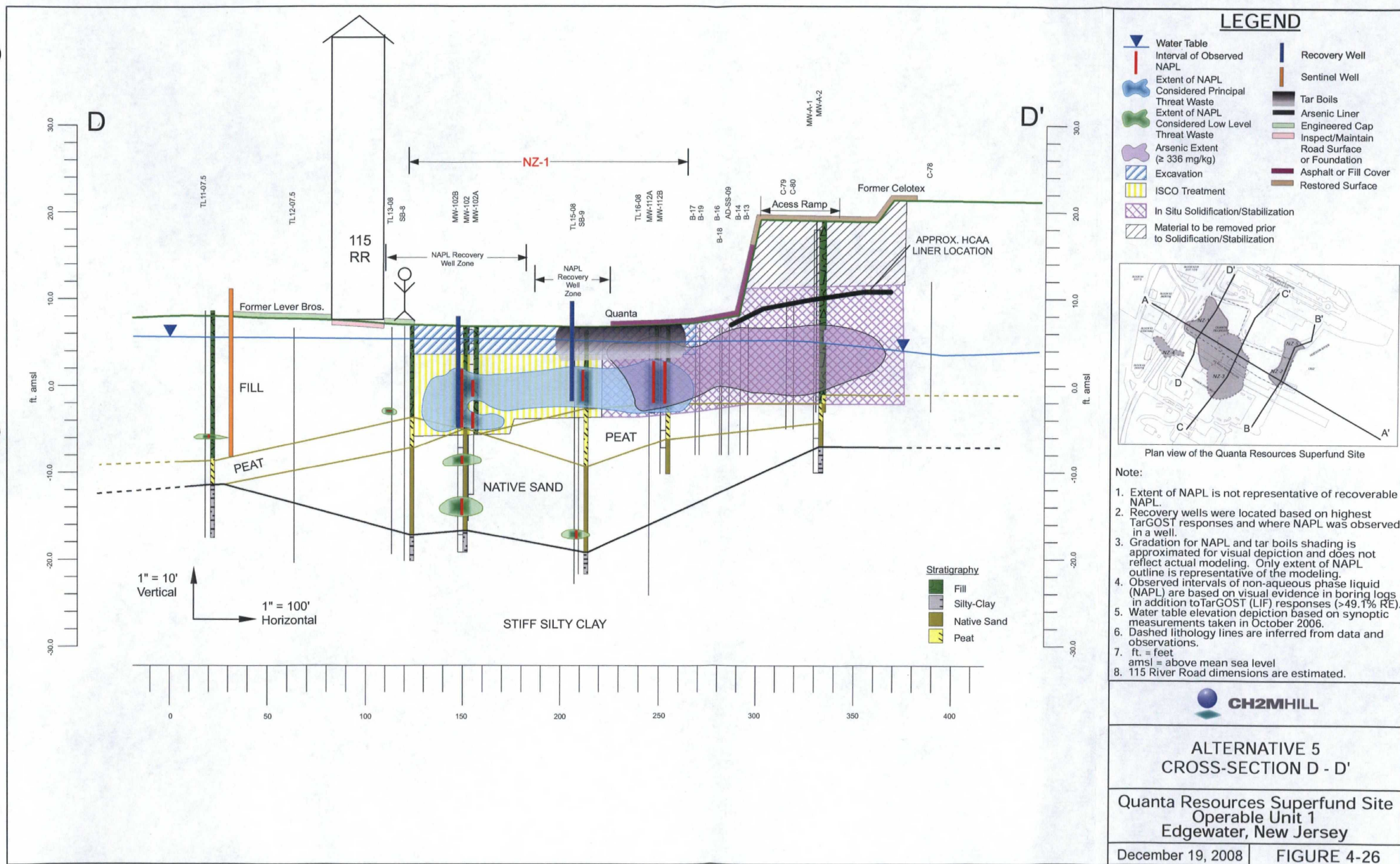


ALTERNATIVE 5 CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

FIGURE 4-25



months to 1 year apart). Similar restrictions apply to Fenton's, since it would not be safe to inject at more than about 15 percent solution. The high oxidant demand required to appreciably reduce VOC and SVOC concentrations (albeit not to levels low enough to approach preliminary remediation goals) apply to any chemical oxidation technology for the site, not only Fenton's and persulfate.

Although oxidation was the primary mechanism for loss of VOCs and SVOCs, even small amounts of increased volatilization may pose potential risks associated with vapor intrusion, which would need to be evaluated and controlled during field implementation. The increases in arsenic concentrations observed in the silty sand samples as a result of ISCO would also need to be monitored and managed during field implementation. The potential for mobilization of currently residual NAPL as a result of the heat of reaction and the physical injection of reagents will need to be thoroughly evaluated prior to field implementation. Engineering controls would need to be robust enough to mitigate the potential risk of NAPL mobilization.

Relocation of occupants in nearby buildings during oxidation is not anticipated to be required. Implementation of engineering controls to control the generation and migration of vapors during subsurface chemical reactions will be required to protect the community and ecological receptors in the Hudson River. The presence of subsurface features and nearby utility corridors (along River Road) could provide preferential vapor pathways, creating potential vapor intrusion risks and reducing the effectiveness of vapor mitigation measures. These potential risks would require management through engineering controls.

The potential for structural destabilization as a result of ISCO injection near buildings or other surface features and subsurface utilities is a concern, and additional evaluation during pilot-testing and remedial design would be required if this alternative was selected.

Details of the injection patterns, quantity of injectors, and quantity of reagent would be determined during remedial design following treatability pilot testing. The results of the pilot test will have an impact on the final alternative cost. Assumptions used for costing purposes are included in Appendix C.

4.5.2 Arsenic-Contaminated Soil

Soil areas containing arsenic in excess of 336 mg/kg would be solidified/stabilized in situ, as described in Section 4.3.2, to mitigate principal threat potential risk on the Quanta and Block 93 North properties and to minimize leaching on the former Celotex property. Figure 4-22 depicts the areas to be treated with solidification/stabilization as part of Alternative 5. Following completion of the solidification/stabilization, a cover (asphalt or fill) would be placed over the treated area.

4.5.3 Residual Soil

Additional areas where site-related constituents exceed PRGs in shallow soil would be capped with an engineered cap, eliminating the direct contact exposure pathway for this medium, and minimizing erosion. The cap would be placed over the Quanta property and the remaining outdoor remedial areas on the 115 River Road, Block 93 North, Block 93 Central, and Block 93 South properties, replacing existing asphalt or other material with the

engineered cap (Figure 4-27). Caps are assumed to be comprised of materials as described in Section 4.2.3 for Alternative 2.

4.5.4 Vapor

The basements of the 115 River Road building would be upgraded with engineered subslabs and converted to actively ventilated crawl spaces as described in Section 4.2.4.

Vapor intrusion mitigation measures would be installed and maintained in other occupied buildings, if needed, as determined by periodic indoor air sampling or other vapor intrusion evaluations.

4.5.5 Groundwater

Groundwater that discharges in the Hudson River, or OU2, would be treated by an SRB as described in Section 4.2.5 and preliminarily depicted on Figure 4-20.

4.5.6 Institutional Controls

Dredging Restrictions

Institutional controls would be established to restrict dredging or other activities that could compromise the integrity of the SRB.

Land Use Restrictions

Alternative 5 reduces exposure to impacted media left in place through placement of engineered caps, solidification/stabilization of NAPL and arsenic, and institutional controls. Institutional controls would consist of land-use restrictions as described in Section 4.2.6. However, since the arsenic cap would no longer be in place, the inspection and maintenance requirements in AOC CERCLA-02-2003-2014 between EPA and Edgewater Enterprises, LLC, would no longer apply.

Groundwater Use Restrictions

Groundwater use restrictions in the form of a CEA would be implemented as described in Section 4.2.6 and would remain in place until COC concentrations are below PRGs.

4.6 Alternative 6—Excavation

Alternative 6 combines excavation of principal threat waste and the HCAA on the former Celotex property with capping of residual soils. In-situ treatment of dissolved COCs in groundwater discharging to the Hudson River would be treated by means of an SRB. This alternative also includes the maintenance of existing roads and parking surfaces and implementation of institutional controls and vapor mitigation measures.

Alternative 6 addresses principal threats identified in Section 1.10 as described below and shown in Table 4-1:

- Toxicity potential due to direct human contact with source material (principal threat waste at NZ-1, NZ-2, tar boils, and the HCAA on the Quanta property and Block 93 North) will be mitigated through excavation and offsite disposal.

- The unoccupied basements of 115 River Road will be converted to crawl spaces with new subslabs, vapor barriers, and active ventilation. Other occupied buildings will be sampled periodically, and if vapor intrusion is identified, mitigation will be provided as needed.
- Mobility potential for free-phase NAPL (principal threat risk at NZ-2 and NZ-5) and toxicity potential for ecological receptors at OU2 is eliminated through the excavation and offsite disposal of source material.

Excavation and offsite disposal prevents the leaching of COCs from the low-level threat source materials in the HCAA on the former Celotex property and areas of collocated NAPL and arsenic source material.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of an SRB. Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable, as described in Section 2.5; however, fate and transport evaluations presented in the final RI (CH2M HILL, 2008a) indicate that the contaminant plume is stable.

The following sections provide a brief description of the components that are incorporated into Alternative 6.

4.6.1 Non-Aqueous Phase Liquid

Soil from locations at which tar boils have been observed and areas of soft, plastic, or hard tars in the vadose zone on the Quanta property would be excavated to a depth of 4 feet bgs. The remaining accessible portions of NAPL zones posing a principal threat would be excavated to depths defined in Section 1.7.1 and disposed offsite. For costing purposes, it is assumed the existing wooden bulkhead would not need to be removed; however, this will need to be confirmed in the remedial design. Soil underneath the 115 River Road building would not be excavated because the exposure pathway can be addressed via institutional and engineering controls.

Figure 4-28 depicts the areas to be excavated as part of this alternative. Figures 4-29 through 4-32 depict this alternative in cross-section view. Excavations below 4 feet would require dewatering. Water extracted for dewatering would be treated onsite and discharged to the Hudson River.

Large-scale excavations requiring dewatering may result in unforeseen impacts to the site. Such impacts may include additional release of site-related constituents including NAPL into OU2 and potential mobilization of previously stable NAPL. Engineering controls would need to be robust enough to mitigate the potential risk of erosion or NAPL mobilization.

Air monitoring would be important during excavation and to evaluate the appropriate PPE for workers. In addition, emission control techniques such as the use of dust and odor suppressants and minimizing the open working area of the excavation would be employed as needed to minimize adverse effects on workers and the community from volatile emissions of NAPL. Relocation of occupants in nearby buildings is not anticipated.

however, contingency plans would be developed during remedial design in the event that air monitoring suggests temporary relocation is needed. Mitigation measures to reduce adverse impacts to the community from increased truck traffic would need to be evaluated and incorporated into the remedial design.

Soils remaining in place on each property after excavation have been assumed for costing purposes to be left in place beneath backfilled soil cover. Institutional controls would be implemented for all properties to prevent contact with deep residuals left in place following excavation.

The potential for structural destabilization as a result of excavation near buildings or other surface features and subsurface utilities is a concern, and additional evaluation during remedial design would be required if this alternative was selected. The costs of shoring have been included in the cost estimate for Alternative 6.

Details of the excavation extents, equipment to be used, required excavation stabilization measures, and exact volumes of impacted soil to be removed would be based on pre-design investigation and/or remedial design. A verification sampling plan describing the approach to be used to determine the extent of excavations would be finalized during the design phase. Specific stormwater diversion, soil erosion controls, and air monitoring requirements would also be assessed during remedial design, as would controls for mitigating the potential risk of NAPL mobilization to the river. The excavation areas would be backfilled and compacted with certified clean fill material.

Based on a comparison of the NAPL chemical characteristics and soil concentrations, it is anticipated that the excavated soils will be classified as hazardous waste. Onsite stabilization of soils would be necessary prior to their disposal to meet land disposal restrictions. Soil would be stockpiled, stabilized, and then disposed of at an offsite landfill. Details of sampling requirements for excavated soils, required treatment, and disposal options would be finalized during remedial design.

4.6.2 Arsenic-Contaminated Soil

Soil areas containing arsenic in excess of the 336 mg/kg would be excavated and disposed of offsite to mitigate principal threat potential risk on the Quanta and Block 93 North properties and to minimize leaching on the former Celotex property (Figure 4-28).

A portion of the Quanta and former Celotex properties at which concentrations of arsenic greater than 1,000 mg/kg have been detected in soil is currently covered with a multilayer engineered cap to prevent direct contact and infiltration. If Alternative 6 were implemented, the fill material above the arsenic cap, assumed to be approximately 10 feet deep and uncontaminated, would be removed and set aside for reuse at the Site. The actual amount of fill material that can be removed would be determined based on an evaluation of the stability of the adjacent structures and would be finalized during remedial design. It is assumed for the purposes of the FS that approximately 75 percent of the fill material in the solidification/stabilization area could be removed to the depth of the liner (10 feet bgs) and that 25 percent of the fill material closest to the building could be removed to a depth of 4 feet bgs.

A verification sampling plan would be developed during remedial design. Details of the excavation extents, equipment to be used, required excavation stabilization measures, and exact volumes of impacted soil to be removed would be based on predesign investigation or remedial design. Specific stormwater diversion, soil erosion controls, and air-monitoring requirements would also be assessed during remedial design. The excavation areas would be backfilled and compacted with certified clean fill material.

Emission control techniques such as the use of dust suppressants and minimizing the open working area of the excavation would be employed as needed to minimize adverse effects on workers and the community. Relocation of occupants in nearby buildings is not anticipated; however, contingency plans would be developed during remedial design in the event that air monitoring suggested that temporary relocation is needed. Mitigation measures to reduce adverse impacts to the community from increased truck traffic would need to be evaluated and incorporated into the remedial design.

Residents and tenants on the former Celotex property will need to have temporary relocation of access and entrances during remediation and construction activities. The existing access ramp to the property will have to be re-routed during arsenic stabilization.

Based on an evaluation of arsenic concentrations in soil and collocated NAPL, it is anticipated that the excavated soils would not meet TCLP limits. Onsite stabilization of soils would be necessary prior to their disposal to meet land disposal restrictions. Soil would be stockpiled, stabilized, and then disposed of at an offsite landfill. Details of sampling requirements for excavated soils, required treatment, and disposal options would be finalized during remedial design.

4.6.3 Residual Soil

Areas where site-related constituents exceed PRGs in shallow soils that are not excavated would be capped with an engineered cap to prevent direct contact and to minimize erosion (Figure 4-33). The cap would be placed over portions of the Quanta property, 115 River Road, and Block 93 properties and would include replacing existing asphalt or other material. Caps are assumed to comprise the materials described in Section 4.2.3.

4.6.4 Vapor

The basements of the 115 River Road building would be upgraded with engineered subslabs and converted to actively ventilated crawl spaces as described in Section 4.2.4.

Vapor intrusion mitigation measures would be installed and maintained in the occupied buildings at Block 93 and former Level Brothers properties, if needed, as determined by periodic indoor air sampling.

4.6.5 Groundwater

Groundwater that discharges in the Hudson River, or OU2, would be treated by an SRB as described in Section 4.2.5.

4.6.6 Institutional Controls

Land-Use Restrictions

Alternative 6 reduces exposure to impacted media left in place through placement of engineered caps, removal of NAPL and arsenic-contaminated soils, and the implementation of institutional controls as described in Section 4.2.6. However, since the arsenic cap would no longer be in place, the inspection and maintenance requirements in AOC CERCLA-02-2003-2014 between EPA and Edgewater Enterprises, LLC, would no longer apply.

Groundwater Use Restrictions

Groundwater use restrictions in the form of a CEA would be implemented as described in Section 4.2.6 and would remain in place until COC concentrations are below PRGs.

Dredging Restrictions

Institutional controls would be established to restrict dredging or other activities that could compromise the integrity of the SRB.

4.7 Summary of Alternatives

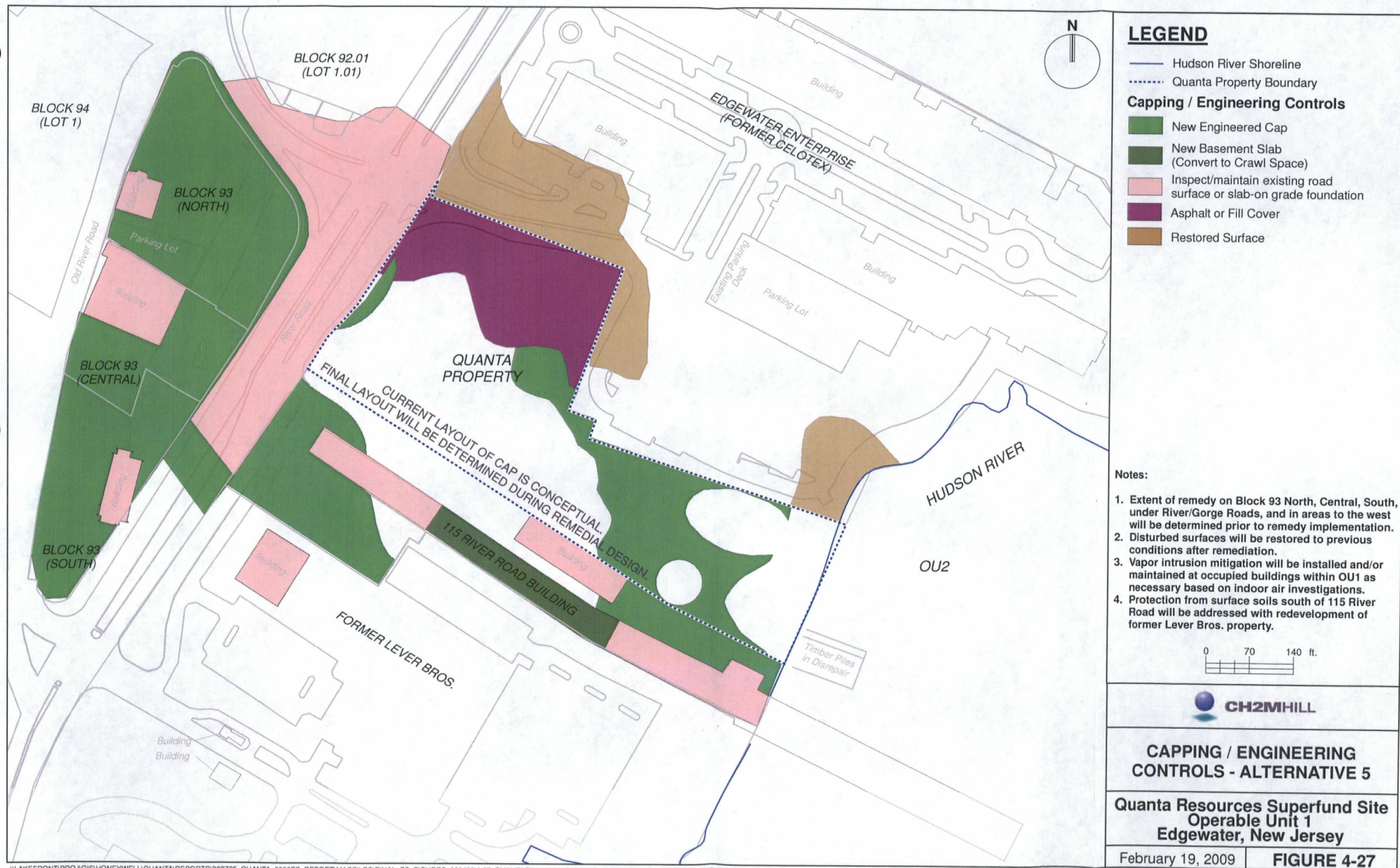
The alternatives developed for the remediation of the OU1 employ a range of technologies including excavation, in situ chemical treatment, in situ solidification/stabilization, capping, engineering controls, NAPL recovery wells and trenches, vapor intrusion mitigation, institutional controls, an SRB, and a funnel and gate system or a PRB. Alternatives 2 through 6 utilize a combination of appropriate technologies to achieve remediation goals. The components of each of the alternatives are briefly summarized in Table 4-2.

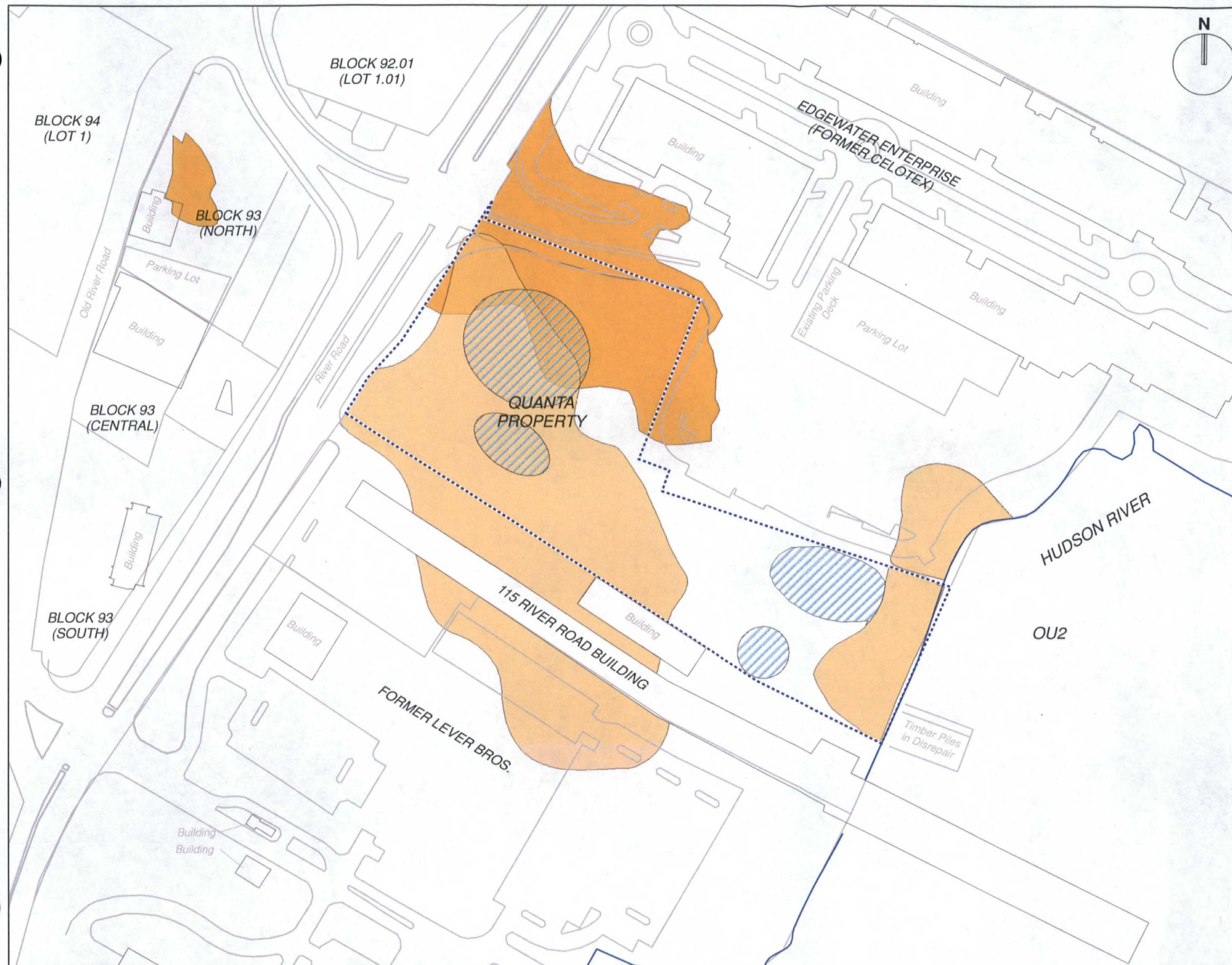
Alternative 1 includes no remedial actions and serves as a baseline for comparison with other alternatives, as required by the NCP. All of the alternatives except Alternative 1 implement institutional controls, maintenance of existing roads and parking surfaces, and some degree of soil capping, an SRB, and vapor mitigation. Alternatives 2 through 6 vary in how they address principal threat NAPL- and arsenic-contaminated soil.

Alternative 2 relies on the containment of contaminants by capping and extraction of free-phase NAPL via recovery wells and trenches. A funnel-and-gate system or PRB would prevent NAPL migration to the Hudson River. Alternative 3 utilizes excavation and solidification/stabilization. NAPL recovery and control against migration to OU2 would occur similar to Alternative 2. Alternative 4 uses in situ solidification/stabilization of all principal threat waste and soil with high arsenic concentrations. Alternative 5 combines excavation, NAPL recovery, in situ chemical treatment of the principal threat NAPL zones, and in situ solidification/stabilization of the arsenic areas. Alternative 6 uses excavation to remove principal threat waste and soil with high arsenic concentrations.

All active alternatives (Alternatives 2 through 6) incorporate the treatment of dissolved-phase COCs in groundwater via an SRB. The SRB serves as a realistic "baseline" technology that is applied to all alternatives, recognizing that some form of groundwater alternative is needed for the site. The evaluation of a final selected groundwater alternative will be performed pending the completion of the SRI and OU2 BERA. The technology to be

implemented will be described in the draft final FS, and the precise size, location, material, and configuration of the selected technology will be determined during remedial design. The final design of the groundwater component for OU1 will be modified as necessary to address potential ecological risks as identified by the OU2 BERA.





LEGEND

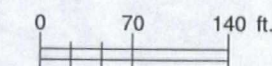
- Quanta Property Boundary
- Hudson River Shoreline

Removal Actions:

- Excavation for NAPL/Tar Boils (0 - 4 ft bgs)
- Excavation for NAPL
- Excavation for Arsenic > 336 mg/kg

Notes:

1. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
2. Final excavation depths will be determined during remedial design.

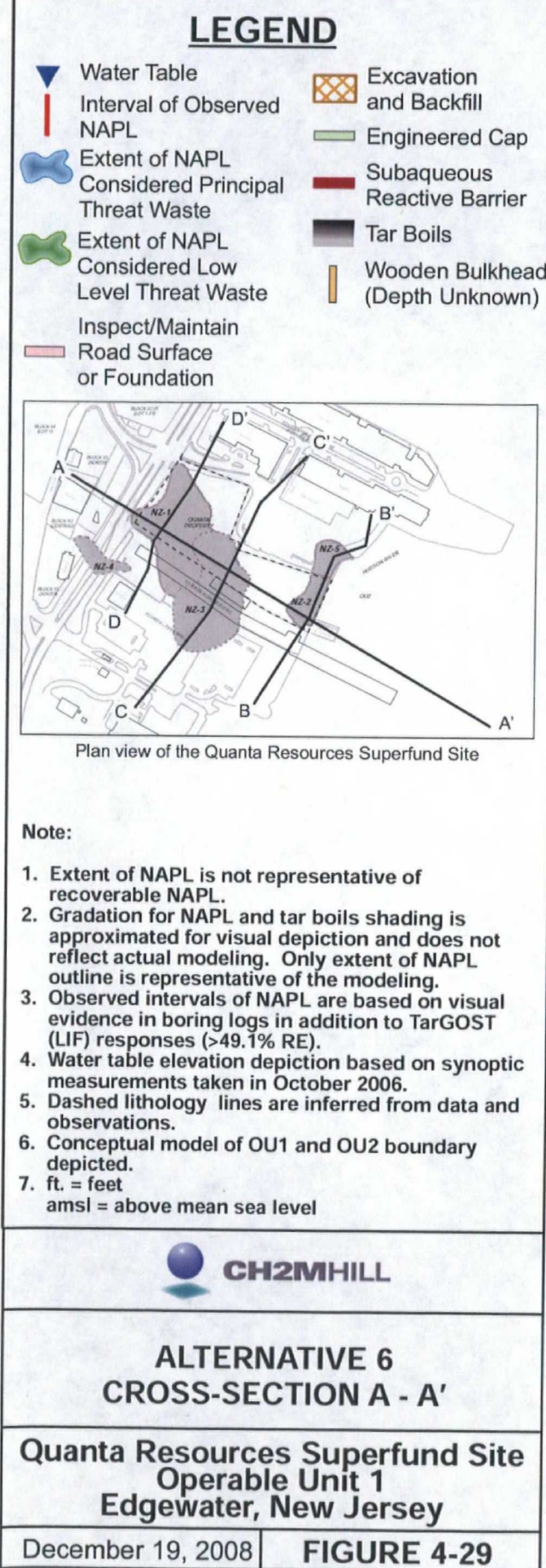
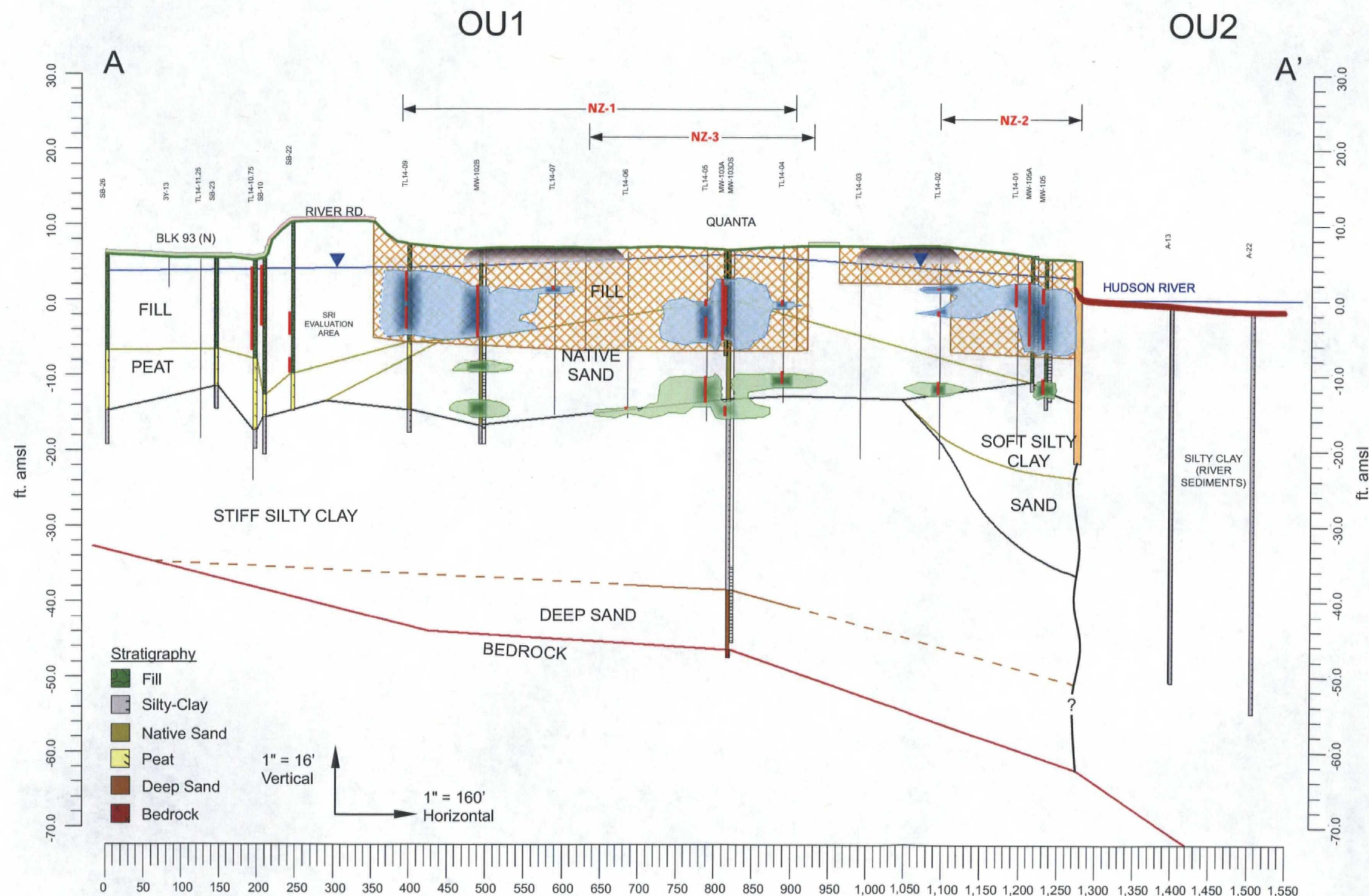


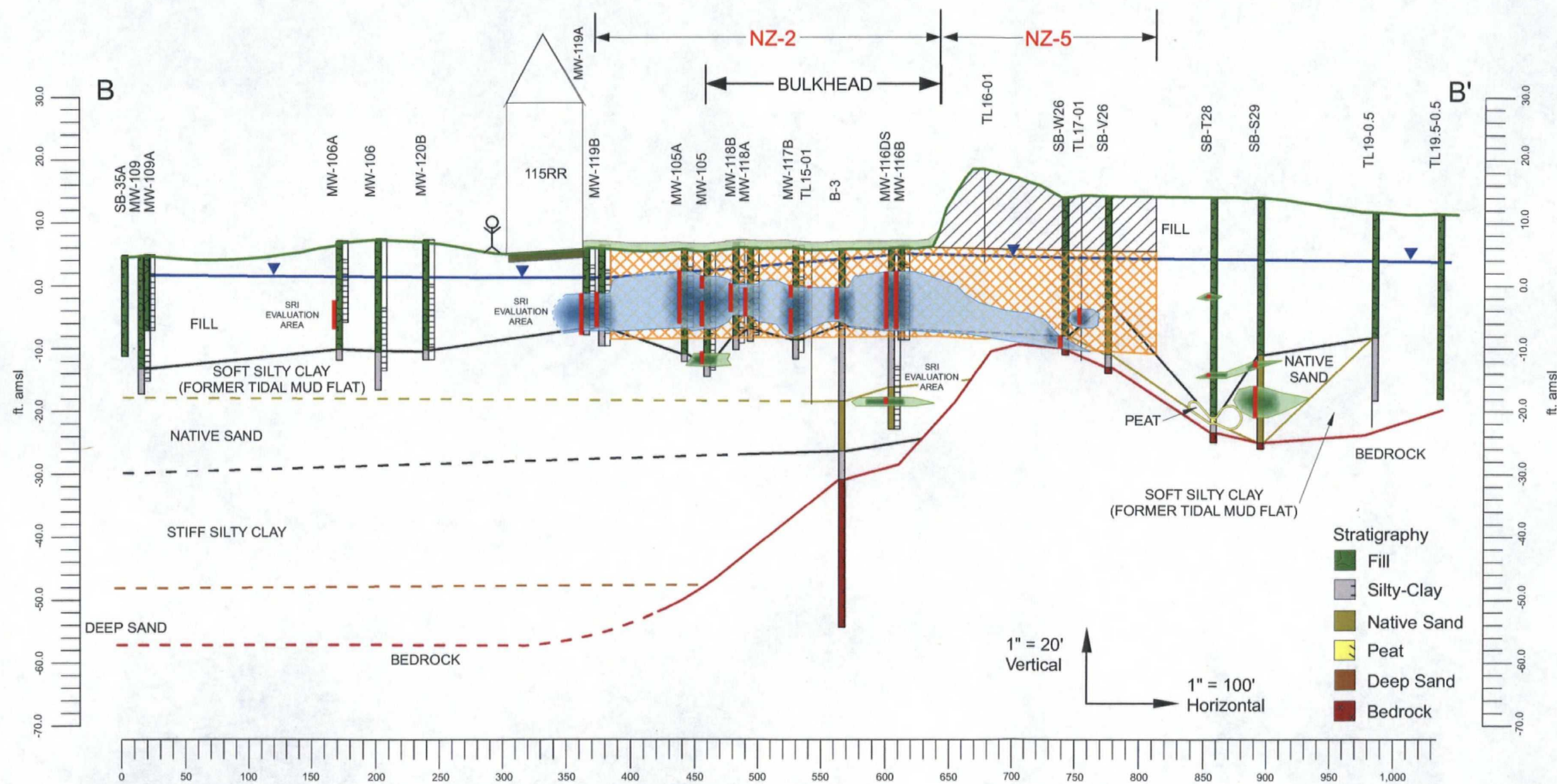
EXCAVATION - ALTERNATIVE 6

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

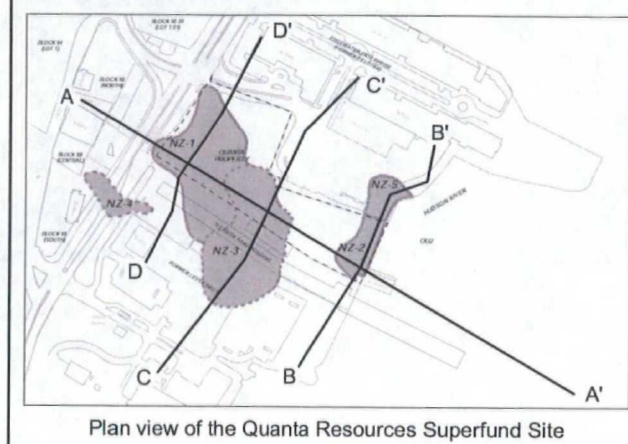
FIGURE 4-28





LEGEND

Water Table	Engineered Cap
Interval of Observed NAPL	Covered Crawl Space
Extent of NAPL Considered Principal Threat Waste	
Extent of NAPL Considered Low Level Threat Waste	
Excavation & Backfill	
Material is Removed but not Disposed Of	



- Notes:
1. Extent of NAPL is not representative of recoverable NAPL.
 2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
 3. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs in addition to TarGOST (LIF) responses (>49.1% RE).
 4. Water table elevation depiction based on synoptic measurements taken in October 2006.
 5. Dashed lithology lines are inferred from data and observations.
 6. Final extent of NZ-2 will be determined based on results of SRI investigation.
 7. ft. = feet
amsl = above mean sea level
 8. 115 River Road dimensions are estimated.

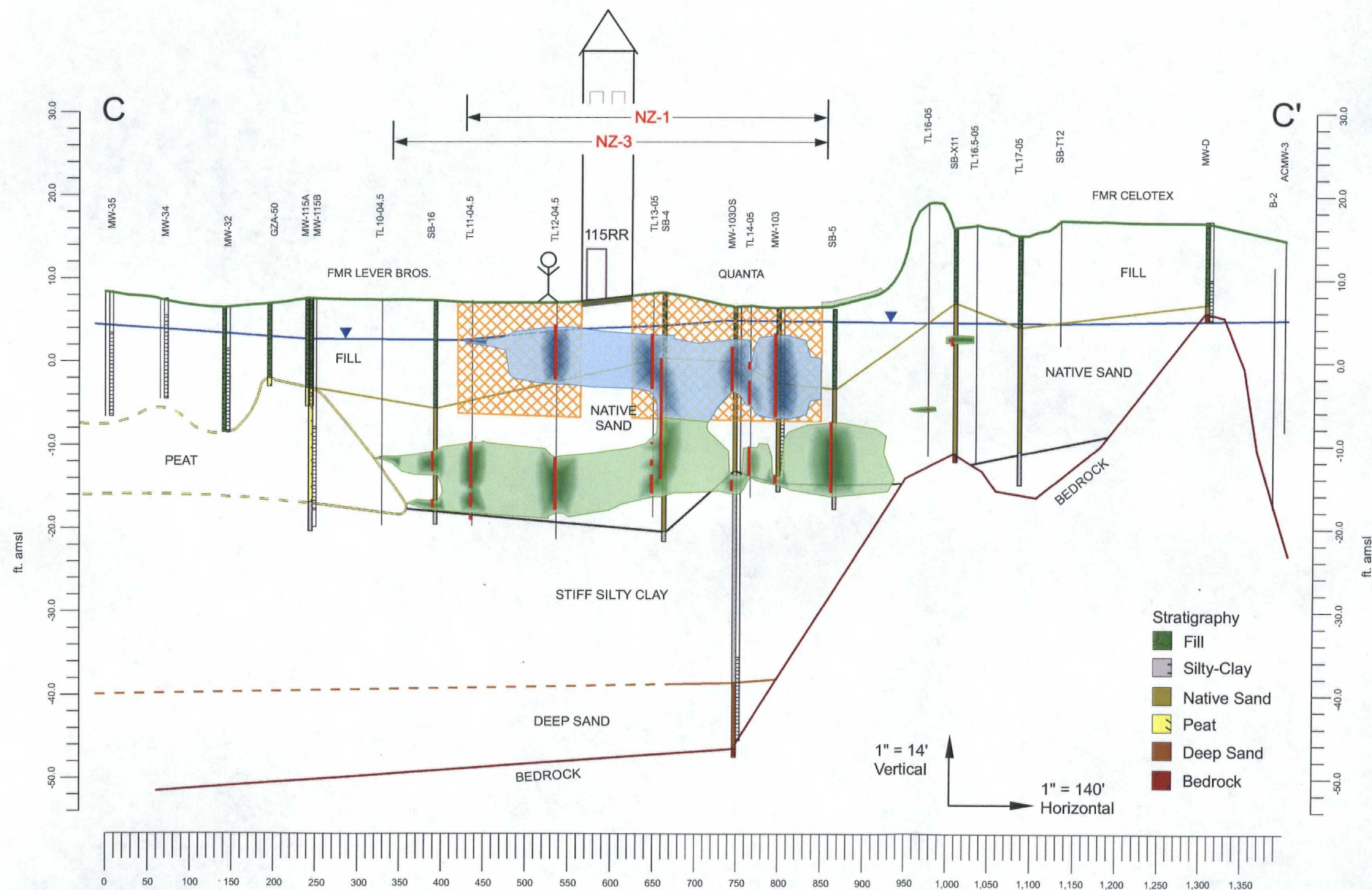
CH2MHILL

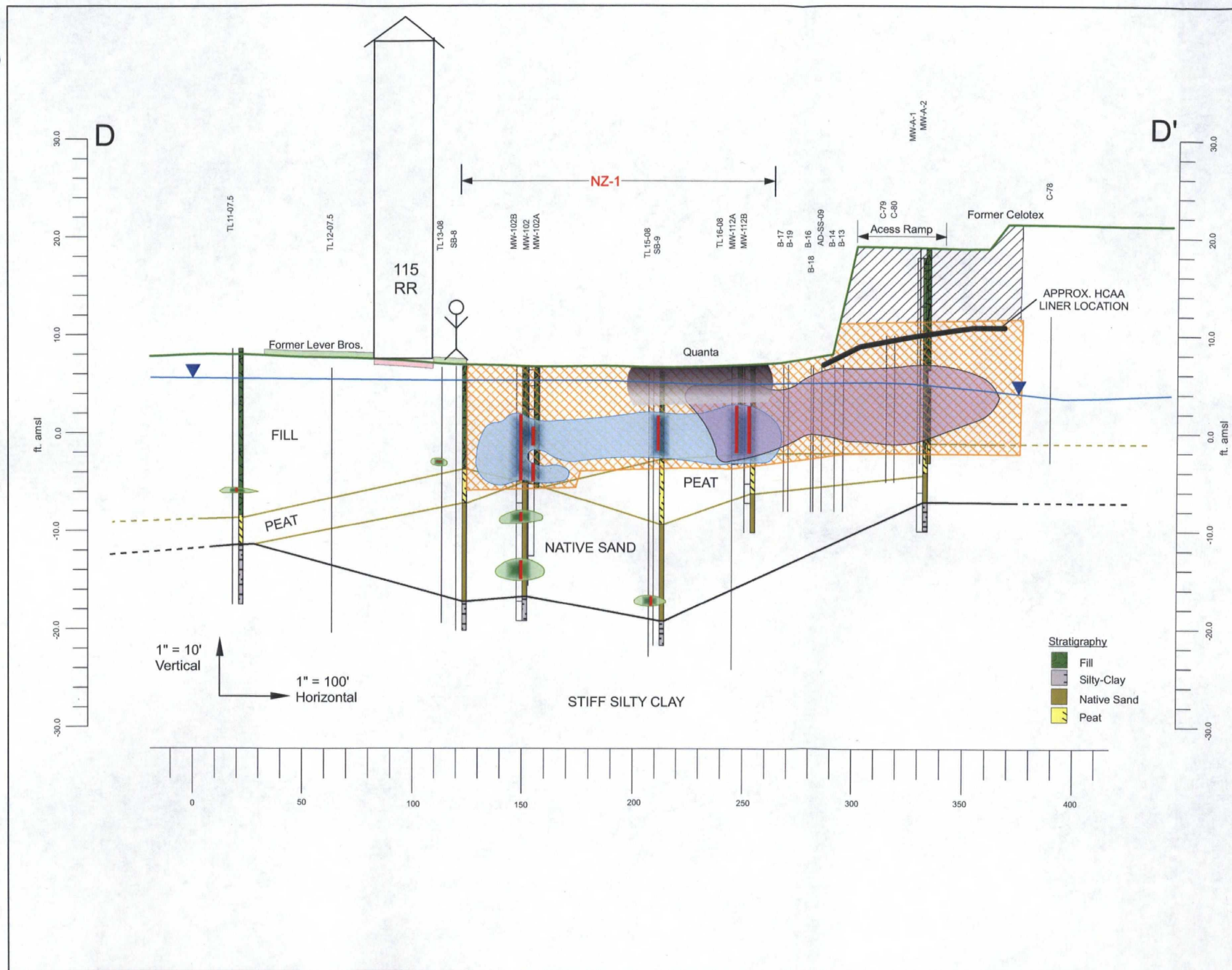
ALTERNATIVE 6
CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

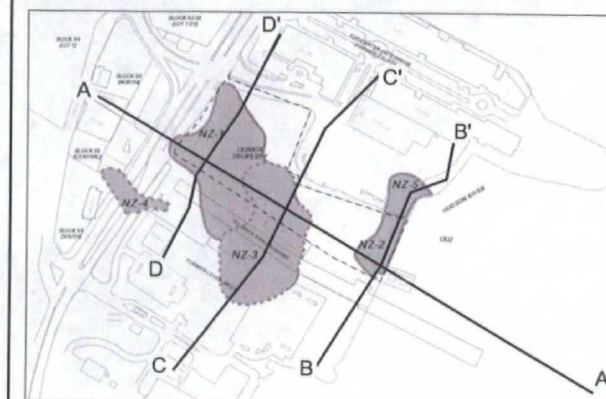
FIGURE 4-30





LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Arsenic Extent (≥ 336 mg/kg)
- Backfill & Excavation
- Material Removed but not Disposed Of
- Tar Boils
- Arsenic Liner
- Engineered Cap
- Inspect/Maintain Road Surface or Foundation



Note:

- Extent of NAPL is not representative of recoverable NAPL.
- Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
- Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs in addition to TarGOST (LIF) responses ($>49.1\%$ RE).
- Water table elevation depiction based on synoptic measurements taken in October 2006.
- Dashed lithology lines are inferred from data and observations.
- ft. = feet
- amsl = above mean sea level
- 115 River Road dimensions are estimated.



ALTERNATIVE 6 CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

December 19, 2008

FIGURE 4-32



LEGEND

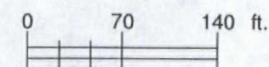
- Hudson River Shoreline
- Quanta Property Boundary

Capping/Engineering Controls

- Engineered Cap
- Inspect/maintain existing road surface or slab-on grade foundation
- New Engineered Cap
- New Basement Slab (Converted to Crawl Space)

Notes:

1. Disturbed surfaces will be restored to previous conditions after remediation.
2. Protection from surface soils south of 115 River Road will be addressed with redevelopment of former Lever Bros. property.
3. Extent of remedy on Block 93 North, Central, South, under River/Gorge Roads, and in areas to the west will be determined prior to remedy implementation.
4. Vapor intrusion mitigation will be installed and/or maintained at occupied buildings within OU1 as necessary based on indoor air investigations.
5. Required extent of new engineered cap as shown; final extent to be determined during remedial design.



CAPPING / ENGINEERING CONTROLS - ALTERNATIVE 6

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

February 19, 2009

FIGURE 4-33

TABLE 4-2
Summary of Feasibility Study Alternatives
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Alternative	NAPL	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
2—Containment	<p>Tar boils at the ground surface throughout the site and shallow NAPL areas would be capped. NAPL would be collected via 14 recovery wells located in NZ-1, and NZ-5 and two trenches located in NZ-2 near the Hudson River. Institutional controls would be established to document and limit use of areas with COCs remaining in place.</p> <p>A funnel and gate system or permeable reactive barrier would be installed to prevent potential NAPL migration to the Hudson River.</p>	The existing High Concentration Arsenic Area (HCAA) liner would be maintained, and the other arsenic-contaminated soils >336 ppm would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place.	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	The basement of 115 River Road would be converted to a crawl space with ventilation. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.
3—Containment, Excavation, and In Situ Solidification/Stabilization	<p>Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils will be excavated to a depth of 4 ft bgs for off-site disposal. NAPL would be collected via 14 recovery wells located in NZ-1 and NZ-5 and two trenches located in NZ-2 near the Hudson River. Institutional controls would be established to document and limit use of areas with COCs remaining in place.</p> <p>A funnel and gate system or permeable reactive barrier would be installed to prevent potential NAPL migration to the Hudson River.</p>	Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic liner and the liner would be removed, and the fill will be reused to the extent practicable. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place.	Same as above	Same as above	Same as above
4—In Situ Solidification/Stabilization	In situ solidification/stabilization of tar boils, NAPL present in NZ-1, NZ-2, and NZ-5. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place.	Same as above	Same as above	Same as above	Same as above
5—In Situ Solidification/Stabilization and In Situ Chemical Treatment	Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft bgs for off-site disposal. NAPL would be collected via 14 recovery wells located in NZ-1, and NZ-5 and two trenches located in NZ-2 near the Hudson River. NAPL collection would be followed by in situ chemical treatment in NAPL zones NZ-1, NZ-2, and NZ-5. Injection points would be placed adjacent to 115 River Road, but not beneath it.	Same as above	Same as above	Same as above	Same as above
6—Excavation	NAPL zones and tar boils would be excavated from accessible areas and disposed of off-site. Excavation would require dewatering to achieve depths greater than 4 feet, and may require shoring near existing structures. Water generated from dewatering activities would be treated on site prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade.	Areas with arsenic concentrations greater than 336 mg/kg would be excavated from accessible areas including material beneath the existing liner and disposed of off-site. Excavations to depths greater than 4 feet would require dewatering, and may require shoring near existing structures. Water generated from dewatering activities would be treated on site prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade.	Same as above	Same as above	Same as above

SECTION 5

Detailed Analysis of Alternatives

The detailed analysis of alternatives presents the relevant information needed to compare the remedial alternatives assembled for OU1. Screening of alternatives was not needed because the number of alternatives was not excessive for detailed evaluation. Detailed analysis of alternatives consists of the following components:

- A detailed evaluation of each alternative against seven of the nine NCP evaluation criteria (the final two criteria, community acceptance and state acceptance, are to be completed later after public comment)
- A comparative evaluation

The complete detailed evaluation of each alternative is presented in Tables 5-1 through 5-5. The comparative evaluation presented in Section 5.2 highlights the most important factors distinguishing the alternatives.

5.1 Evaluation Criteria

In accordance with the NCP, remedial actions must:

- Be protective of human health and the environment
- Attain ARARs or provide grounds for invoking a waiver of ARARs that cannot be achieved
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces TMV as a principal element

In addition, the NCP emphasizes long-term effectiveness and related considerations including:

- Long-term uncertainties associated with land disposal
- Goals, objectives, and requirements of the Solid Waste Disposal Act
- Persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate
- Short- and long-term potential for adverse health effects from human exposure
- Long-term maintenance costs
- Potential for future remedial action costs if the selected remedial action fails

- Potential threat to human health and the environment associated with excavation, transportation, disposal, or containment

Provisions of the NCP require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria were published in the March 8, 1990, *Federal Register* (55 FR 8666) to provide grounds for comparison of the relative performance of the alternatives and to identify their advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to select the most appropriate alternative for implementation at the site. The criteria are divided into three groups: threshold, balancing, and modifying criteria. Threshold criteria must be met by for an alternative to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—either they are met by a particular alternative, or that alternative is not considered acceptable. The two threshold criteria are (1) overall protection of human health and the environment and (2) compliance with ARARs. If ARARs cannot be met, a waiver may be obtained in situations where one or more of the six exceptions listed in the NCP occur (see 40 CFR 300.430 (f)(1)(ii)(C)(1 to 6).

Unlike the threshold criteria, the five balancing criteria weigh the tradeoffs between alternatives. A low rating on one balancing criterion can be compensated by a high rating on another. The five balancing criteria are

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

The two modifying criteria—community acceptance and state acceptance—are evaluated following public comment and are used to change (or confirm) the selection of the recommended alternative.

5.1.1 Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criteria, or if an ARAR is not met, justify that a waiver is appropriate. The performance of each of the alternatives against the threshold criteria is evaluated in Tables 5-1 through 5-5.

Overall Protection of Human Health and the Environment

Protection is the primary requirement that remedial actions must meet under CERCLA. A remedy is protective of human health and the environment if it adequately eliminates, reduces, or controls all current and potential risks posed by the site through exposure pathways. If an exposure pathway is not present, there is no potential for risk. The evaluation of each alternative in consideration of this criterion addresses how the alternative achieves and maintains protection of human health and the environment.

TABLE 5-1
Detailed Evaluation of Alternative 2—Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
Description of remedy	<p>Tar boils at the ground surface throughout the site and shallow NAPL areas would be capped. NAPL would be collected via 14 recovery wells located in NZ-1, and NZ-5 and two trenches located in NZ-2 near the Hudson River. Institutional controls would be established to document and limit use of areas where constituents remains in place.</p> <p>A funnel and gate system or permeable reactive barrier would be installed to prevent potential NAPL migration to the Hudson River.</p>	<p>The existing High Concentration Arsenic Area (HCAA) cap would be maintained and the other arsenic-contaminated soils greater than 336 ppm would be capped. Institutional controls would be established to document and limit use of areas with constituents remaining in place.</p>	<p>Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.</p>	<p>The basement in the 115 River Road building would be converted to a crawl space with ventilation. Institutional controls would be established and maintained to prevent vapor intrusion into new buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and Former Lever Brother properties, as needed.</p>	<p>A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established.</p>
1. Overall Protection of Human Health and the Environment					
	<p>Extraction system would reduce the amount of free-phase NAPL in the subsurface; however, the portion of the total mass that can be removed by this method is limited. Constituents would continue to leach to groundwater.</p> <p>The potential for direct exposure to principal threat waste would be minimized through capping and institutional controls.</p> <p>Extracted NAPL would be stored in locked sheds and periodically removed and disposed offsite. NAPL would be contained in tanks/drums with secondary containment.</p> <p>Funnel and gate or permeable reactive barrier would inhibit the potential migration of principal threat material to the Hudson River.</p>	<p>Contaminants would remain in place.</p> <p>Existing liner, additional capping and institutional controls would mitigate the principal threat potential risk of human exposure through direct contact.</p> <p>Existing liner and capping will minimize the infiltration rate; however, groundwater would continue to flow through affected soils, leaching constituents to groundwater.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with principal threat waste.</p>	<p>Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil.</p> <p>Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.</p>	<p>Alternative would provide vapor barrier and limit access to 115 River Road basements, which reduces inhalation potential.</p> <p>Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements.</p> <p>Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings.</p> <p>Vapor mitigation systems would be installed, as needed, in existing buildings.</p>	<p>Reactive barrier treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors.</p> <p>Institutional controls would restrict the use of the groundwater.</p>
2. Compliance with ARARs					
	<p>This alternative complies with the ARAR to treat, remove, or contain free NAPL by extracting free-phase NAPL, to the extent practicable, at locations where it has been observed or inferred to be located based on TarGOST. Additionally, NAPL will be treated by the use of a funnel and gate system or permeable reactive barrier.</p> <p>This alternative would not result in the removal of residual NAPL. Under this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely.</p> <p>NAPL collection, storage, and disposal would be performed in accordance with applicable local, state and federal regulations.</p>	<p>Would not meet soil clean-up standards, but most ARARs would be met because the alternative reduces the direct exposure to constituents above the cleanup goal. ARARs concerned with leaching to groundwater would not be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	<p>ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	<p>The ARARs for vapor intrusion would be met as 115 River Road Building would undergo remedy to reduce potential vapor intrusion. 115 River Road and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.</p>	<p>The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria.</p> <p>Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.</p>

TABLE 5-1
Detailed Evaluation of Alternative 2—Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	<p>Alternative includes active collection of free-phase NAPL; however, long-term potential risk related to the residual NAPL that remains would continue indefinitely.</p> <p>Long-term residual potential risks would also remain from free-phase NAPL present in areas that are outside the radius of influence of the NAPL collection sumps.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls. Soil contamination would remain relatively unchanged since arsenic is not biodegradable.</p> <p>Leaching would diminish, although lateral infiltration and subsequent leaching would occur.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Potential risks due to contamination left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged.</p> <p>Leaching would diminish, although lateral infiltration and subsequent leaching would occur.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain.</p> <p>Potential risks would be controlled by new slabs in converted crawl spaces at 115 River Road and maintenance of institutional controls and vapor mitigation.</p> <p>Magnitude of potential risk in buildings would be maintained below appropriate standards.</p> <p>Chosen methods are proven technologies for vapor mitigation.</p>	<p>Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions.</p> <p>Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.</p>
(b) Adequacy and reliability of controls	<p>NAPL recovery is a reliable, proven technology, with multiple vendors for equipment supply.</p> <p>Permeable reactive barriers are a new technology.</p> <p>Performance monitoring is a critical component of the remedy.</p> <p>Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p>	<p>Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p> <p>Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.</p>	<p>Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p> <p>Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.</p>	<p>Vapor mitigation would be reliable with proper maintenance and access restrictions.</p> <p>Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.</p>	<p>Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy.</p> <p>Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.</p>
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	Recovered NAPL would be disposed of offsite. Offsite disposal of NAPL is assumed to consist of asphalt batching.	No treatment used.	No treatment used.	Vapor intrusion would be mitigated by the concrete slabs in the converted and ventilated crawl spaces in the 115 River Road building. Vapor intrusion mitigation would be applied to other buildings if and as needed.	Groundwater constituents would be treated/adsorbed before discharging to surface water.
(b) Degree and quantity of TMV reduction	<p>The volume of free-phase NAPL would be reduced through recovery, although significant quantities of residual NAPL would remain in the subsurface. The total mass of NAPL to be removed would likely be a small percentage of the overall mass.</p> <p>Toxicity and mobility via leaching to groundwater from remaining NAPL would continue.</p>	<p>Toxicity and volume of arsenic impacted soil would remain.</p> <p>Mobility of arsenic impacted soils would be reduced through the maintenance of the liner and existing road surfaces; however, mobility via leaching to groundwater would continue.</p>	<p>Toxicity and volume of residual soil contamination would remain.</p> <p>Mobility of residually impacted soils would be reduced through the maintenance of the cap, the liner and existing road surfaces; however, mobility via leaching to groundwater would continue.</p>	<p>Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Road basements.</p> <p>Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed.</p> <p>Toxicity, mobility, and volume of contamination in underlying soils would remain.</p>	Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River.

TABLE 5-1
Detailed Evaluation of Alternative 2—Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(c) Irreversibility of TMV reduction	NAPL recovery is irreversible. Permeable reactive barrier treatment may be reversible if barrier is compromised or destroyed or if adsorption sites are saturated up, allowing desorption to occur. Monitoring of the permeable reactive barrier would be conducted to predict when replacement or maintenance may be required.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed. Subaqueous reactive barrier treatment may be reversible if adsorption sites become saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required.
(d) Type and quantity of treatment residuals	Extracted NAPL is estimated to be 1,000 gallons per year. Residual NAPL would remain in the subsurface.	Arsenic contaminated soils would remain on site but access and infiltration would be controlled.	Impacted soils would remain on site but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin.
(e) Statutory preference for treatment	Preference would be met for removed free-phase NAPL but not for NAPL remaining in subsurface.	Would not meet NJDEP preference for treatment of arsenic in soil; however, capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference met for groundwater because it would be treated before discharging to the river.
(f) Sustainability	Effectively minimizes need for transportation and disposal of generated waste. Recovered NAPL will potentially be recycled.	Effectively minimizes need for transportation and disposal of generated waste. Unsustainable in that future land uses are restricted by untreated wastes left in place.	Effectively minimizes need for transportation and disposal of generated waste. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production and capping and would effectively reduce the volume of surface water runoff. Unsustainable in that future land uses are restricted by untreated wastes left in place.	No significant impacts. Unsustainable in that future land uses are restricted by untreated wastes left in place	Energy efficient remedy using natural process rather than mechanical systems. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies. Unsustainable in that groundwater is not restored to drinking water quality
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	Potential risk to workers during remedial construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during construction of subslab and installation of vapor mitigation in basement.	Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
(b) Protection of community during remedial action	Potential risks to the community during remedial construction include generated vapors and odor during construction activities, as well as safety risks from the presence of deep open trenches. These risks would be mitigated during implementation through use of engineering controls. Operation and maintenance of NAPL recovery would require periodic transport of NAPL offsite. Appropriate health and safety, storage, and handling procedures must be followed.	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the subslabs.	Minimal potential risks to the community during construction of the subaqueous reactive barrier. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans. Engineering controls would be utilized to protect community from noise.

TABLE 5-1
Detailed Evaluation of Alternative 2—Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(c) Environmental impacts of remedial action	<p>Minimal potential risks to the environment during extraction well installation, and trenching and funnel and gate or permeable reactive barrier installation would be mitigated by implementation of adequate erosion controls and proper handling of remediation-generated wastes.</p> <p>Potential risk of NAPL mobilization during construction of permeable reactive barrier or funnel and gate system.</p>	<p>Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.</p>	<p>Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.</p>	<p>Minimal potential risks to the environment during construction activities.</p>	<p>Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension.</p> <p>Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water.</p> <p>Potential temporary river habitat destruction during reactive barrier construction.</p>
(d) Time until RAOs are achieved	<p>Anticipated that all recoverable NAPL would be removed in an estimated 20-30 years from onset of implementation.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities.</p>	<p>The RAOs to minimize potential exposure to soils would be met immediately following cap construction and establishment of institutional controls.</p> <p>The RAO to prevent erosion would be met immediately following cap construction.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities.</p>	<p>The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls.</p> <p>The RAO to prevent erosion would be met immediately following cap construction.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities.</p> <p>Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.</p>	<p>The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following conversion of basements to crawl spaces in the 115 River Road building and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings if and as needed</p>	<p>The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier</p> <p>Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met prior to reaching the subaqueous reactive barrier.</p>
6. Implementability					
(a) Technical feasibility	Feasible.	Feasible.	Feasible.	Feasible.	<p>Use of subaqueous reactive barriers is technically feasible pending results of bench- and pilot-scale testing.</p> <p>Subaqueous reactive barriers are considered an innovative technology.</p>
(b) Administrative feasibility	Administratively feasible; however, access to properties would be needed for construction activities.	Administratively feasible; however, access would be needed for cap installation and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.	Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.

TABLE 5-1
Detailed Evaluation of Alternative 2—Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
7. Total Present Worth Cost					
Total present worth cost range*	\$22,295,000 to \$ 47,775,000				

* The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the FS, the SRI and/or during engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix C.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
NAPL non-aqueous phase liquid
NJDEP New Jersey Department of Environmental Protection
OU1 Operable Unit 1
OU2 Operable Unit 2
PRG preliminary remediation goal
RAO remedial action objective
TMV toxicity, mobility, or volume
VOC volatile organic compound

TABLE 5-2
Detailed Evaluation of Alternative 3—Containment, Excavation and In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
Description of Remedy	<p>Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft for offsite disposal. Shallow NAPL areas throughout the site would be capped. NAPL would be collected via 14 recovery wells located in NZ-1, NZ-3, and NZ-5 and two recovery trenches located in NZ-2 near the Hudson River. Institutional controls would be established to document and limit use of areas where constituents remains in place.</p> <p>A funnel-and-gate system or permeable reactive barrier would be installed to prevent potential NAPL migration to the Hudson River.</p>	<p>Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic liner and the liner would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with constituents remaining in place.</p>	<p>Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.</p>	<p>The basements in the 115 River Road building would be converted to crawl spaces with active ventilation. Institutional controls would be established and maintained to control new construction and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and former Lever Brother properties, as needed.</p>	<p>A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established.</p>
1. Overall Protection of Human Health and the Environment					
	<p>Excavation of shallow soils (tar boils, NZ-1 and NZ-2 to 4 ft bgs) and institutional controls would minimize the principal threat risk of exposure through direct contact.</p> <p>Extraction system would reduce the amount of free phase NAPL in the subsurface; however, the portion of the total mass that can be removed by this method is limited. Constituents would continue to leach to groundwater.</p> <p>The potential for exposure to the NAPL in-the subsurface would be minimized through capping and institutional controls.</p> <p>Extracted NAPL would be stored in locked sheds and periodically removed and disposed offsite. NAPL would be contained in drums and tanks with secondary containment.</p> <p>Funnel and gate or permeable reactive barrier would inhibit NAPL migration to the Hudson River.</p>	<p>Solidification/stabilization would prevent direct contact/ingestion risk.</p> <p>The principal threat risk of exposure to arsenic source materials would be minimized through solidification/stabilization and institutional controls.</p> <p>Constituents remain in place; however, solidification/stabilization would be designed to eliminate leaching of constituents under normal groundwater geochemical conditions.</p> <p>Shallow stabilization would minimize the infiltration rate; however, groundwater would continue to flow through affected soils, leaching constituents to groundwater.</p> <p>Institutional controls for all properties would identify the areas of soil contamination left in place exceeding PRGs and minimize the potential for damage to caps and/or contact with contaminated subsurface soil.</p>	<p>Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils.</p> <p>Institutional controls for all properties would identify the areas of soil contamination left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil.</p> <p>Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.</p>	<p>Alternative would provide vapor barrier and limit access to 115 River Road basements, which reduces inhalation potential.</p> <p>Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements.</p> <p>Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings.</p> <p>Vapor mitigation systems would be installed, as needed, in existing buildings.</p>	<p>Reactive barrier treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors.</p> <p>Institutional controls would restrict the use of the groundwater.</p>

TABLE 5-2

Detailed Evaluation of Alternative 3—Containment, Excavation and In Situ Solidification/Stabilization
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
2. Compliance with ARARs					
	<p>This alternative complies with the ARAR to treat, remove, or contain free NAPL by extracting free phase NAPL, to the extent practicable, at locations where it has been observed or inferred to be located based on TarGOST. Additionally, NAPL will be contained by the use of the funnel and gate system or the permeable reactive barrier.</p> <p>This alternative would not result in the removal of residual NAPL. Under this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely.</p> <p>NAPL collection, storage, and disposal would be performed in accordance with applicable local, state and federal regulations.</p>	<p>This alternative would comply with arsenic ARARs by mitigating the potential risks associated with ingestion or direct contact. In addition, leaching through the surface would be greatly reduced.</p> <p>Meets ARAR for controlling potential risk in soil by treating soil containing residual arsenic which reduces the exposure to constituents above the cleanup goal. Dust emissions from stabilization would be controlled as necessary to meet Clean Air Act ARARs.</p> <p>ARARs would be met because cap integrity would be maintained through regular inspections and repairs, and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	<p>ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	<p>The ARARs for vapor intrusion would be met as 115 River Road Building would undergo remedy to reduce potential vapor intrusion; 115 River Road and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.</p>	<p>The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria.</p> <p>Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.</p>
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	<p>Alternative includes active collection of free phase NAPL; however, long-term potential risk related to the residual NAPL that remains would continue indefinitely.</p> <p>Potential long-term residual risks would remain from free-phase NAPL present in areas that are outside the radius of influence of the NAPL collection sumps.</p> <p>Once excavation is completed, potential residual risks for the residential and construction worker exposure scenarios on most properties would be eliminated. Constituents left in place beneath the excavation depths would be covered by clean backfill and capped.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Potential risks due to constituents left in place would be greatly reduced because infiltration and leaching would be greatly reduced. This would be verified and demonstrated by bench- and/or pilot-tests, tests of solidified/stabilized soils, and periodic groundwater monitoring after soil mixing.</p> <p>The presence of monoliths resulting from solidification/stabilization would impact groundwater flow.</p> <p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls.</p> <p>Solidification/stabilization is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged.</p> <p>Leaching would diminish, although lateral infiltration and subsequent leaching would occur.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain.</p> <p>Potential risks would be controlled by new slabs in converted crawl spaces at 115 River Road and maintenance of institutional controls and vapor mitigation.</p> <p>Magnitude of potential risk in buildings would be maintained below appropriate standards.</p> <p>Chosen methods are proven technologies for vapor mitigation.</p>	<p>Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions.</p> <p>Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.</p>

TABLE 5-2

Detailed Evaluation of Alternative 3—Containment, Excavation and In Situ Solidification/Stabilization
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(b) Adequacy and reliability of controls	<p>The extraction system would remain in place until recovery is reduced to appreciable level.</p> <p>NAPL recovery is a reliable, proven technology, with multiple vendors for equipment supply.</p> <p>Reactive barriers are a new technology.</p> <p>Performance monitoring is a critical component of the remedy.</p> <p>Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p>	<p>Solidified soils and institutional controls are adequate and reliable in preventing direct contact but would require monitoring indefinitely.</p>	<p>Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p> <p>Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.</p>	<p>Vapor mitigation would be reliable with proper maintenance and access restrictions.</p> <p>Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.</p>	<p>Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy.</p> <p>Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.</p>
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	<p>Excavated soil and recovered NAPL would be disposed of offsite. Offsite disposal of NAPL is assumed to consist of asphalt batching.</p> <p>Soils excavated from tar boils, NZ-1, and NZ-2 would be stabilized prior to disposal, as necessary, to meet land disposal requirements.</p>	<p>Arsenic soils impacted over 336 ppm would be solidified/stabilized with reagents mixed in via large diameter augers.</p>	<p>No treatment used.</p>	<p>Vapor intrusion would be mitigated by the concrete slabs in the converted and ventilated crawl spaces in the 115 River Road building. Vapor intrusion mitigation would be applied to other buildings if and as needed.</p>	<p>Groundwater constituents would be treated/adsorbed before discharging to surface water.</p>
(b) Degree and quantity of TMV reduction	<p>The volume of free-phase NAPL would be reduced through extraction and/or recovery although significant quantities of NAPL would remain in the subsurface and the total mass of NAPL to be removed is likely a small percent of the overall mass.</p> <p>Toxicity and mobility via leaching to groundwater from remaining NAPL would continue.</p> <p>Soils removed during excavation would be treated prior to disposal, as necessary, to meet land disposal requirements.</p>	<p>Mobility would be reduced but volume would not be reduced.</p> <p>Leaching of constituents to groundwater would be reduced.</p>	<p>Toxicity and volume of residual soil contamination would remain.</p> <p>Mobility of residually impacted soils would be reduced through the maintenance of the cap, the liner and existing road surfaces; however, mobility via leaching to groundwater would continue.</p>	<p>Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Road basements.</p> <p>Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed.</p> <p>Toxicity, mobility, and volume of contamination in underlying soils would remain.</p>	<p>Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River.</p>
(c) Irreversibility of TMV reduction	<p>NAPL recovery is irreversible.</p> <p>Reactive barrier treatment may be reversible if barrier is compromised or destroyed or if adsorption sites are completely used up, allowing desorption to occur. Monitoring of the RSB would be conducted to predict when replacement may be required.</p>	<p>Solidification/stabilization process immobilizes arsenic in the soil matrix in situ to minimize/eliminate leaching potential.</p> <p>Bench- and pilot-scale testing would be completed to determine the irreversibility of the process. This would be verified by sampling and analysis of solidified/stabilized soils, and groundwater would be monitored after treatment.</p>	<p>Reversible if institutional controls and cap were not maintained.</p>	<p>Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.</p>	<p>Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed.</p> <p>Subaqueous reactive barrier treatment may be reversible if adsorption sites saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required.</p>
(d) Type and quantity of treatment residuals	<p>Extracted NAPL is estimated to be 1,000 gallons per year.</p> <p>NAPL would remain in the subsurface.</p>	<p>Arsenic stabilized in the soil matrix in situ would remain on site.</p>	<p>Impacted soils would remain on site but access and infiltration would be controlled.</p>	<p>Source of vapors would remain in the subsurface.</p>	<p>Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin.</p>

TABLE 5-2

Detailed Evaluation of Alternative 3—Containment, Excavation and In Situ Solidification/Stabilization
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(e) Statutory preference for treatment	Preference would be met for removed free-phase NAPL and excavation of shallow impacted soil, but not for NAPL remaining in the subsurface.	Would meet NJDEP preference for treatment of arsenic in soil.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference met for groundwater because it would be treated before discharging to the river.
(f) Sustainability	<p>High greenhouse gas emissions from excavation equipment, waste transportation and transportation of clean fill to the site.</p> <p>Significant waste generated which would require off-site disposal. Transporting waste from one place to another is not considered sustainable.</p>	<p>Effectively minimizes need for transportation and disposal of generated waste.</p> <p>High greenhouse gas emissions from mixing equipment but of limited duration and balanced by reduced truck traffic impacts.</p> <p>Unsustainable in that future land uses are restricted by treated wastes left in place.</p>	<p>Effectively minimizes need for transportation and disposal of generated waste. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production and capping and would effectively reduce the volume of surface water runoff.</p> <p>Unsustainable in that future land uses are restricted by untreated wastes left in place</p>	<p>No significant impacts.</p> <p>Unsustainable in that future land uses are restricted by untreated wastes left in place</p>	<p>Energy efficient remedy using natural process rather than mechanical systems. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies.</p> <p>Unsustainable in that groundwater is not restored to drinking water quality</p>
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	Potential risk to workers during remedial construction would be mitigated by adherence to a site-specific health and safety plan and engineering controls (e.g., dust suppression, odor control).	<p>Implementation of arsenic solidification/stabilization could result in the potential for additional risk to workers due to high concentrations of arsenic expected to be present in soils within the treatment areas.</p> <p>Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control).</p> <p>Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans.</p>	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during construction of subslab and installation of vapor mitigation in basement.	Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
(b) Protection of community during remedial action	<p>Potential risks to the community during remedial construction include generated vapors, odors, and noise during construction activities, as well as safety risks from the presence of deep open trenches.</p> <p>Engineering controls would be utilized to protect community from dust, vapors, and noise (silencers, black plastic, odor suppressing foam etc.).</p> <p>Potential safety-related risks to the community are associated with the truck traffic to remove excavated soil.</p> <p>Operation and maintenance of NAPL recovery would require periodic transport of NAPL offsite. Appropriate health and safety, storage, and handling procedures must be followed.</p>	<p>Potential risks to the community during solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls.</p> <p>Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor suppressing foam).</p>	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the subslabs.	<p>Minimal potential risks to the community during construction of the subaqueous reactive barrier. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.</p> <p>Engineering controls would be utilized to protect community from noise.</p>

TABLE 5-2
Detailed Evaluation of Alternative 3—Containment, Excavation and In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(c) Environmental impacts of remedial action	Minimal potential risks to the environment during extraction well installation, trenching and funnel and gate or permeable reactive barrier installation would be mitigated by implementation of adequate erosion controls and proper handling of remediation-generated wastes.	Design would include storm water management and management of new groundwater flow pathways. Site runoff during mixing would be controlled by using appropriate erosion controls. Potential risks to the environment include generated vapors, noise, and odors during mixing. These potential risks would be mitigated during implementation through use of engineering controls.	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during construction activities.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water. Potential temporary river habitat destruction during reactive barrier construction.
(d) Time until RAOs are achieved	Anticipated removal of recoverable NAPL would be completed in an estimated 20-30 years from onset of implementation. The RAO to minimize potential exposure through contact, ingestion, and inhalation are achieved when excavation and capping are complete. Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities.	The treatment of the arsenic through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping are complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than one year).	The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be immediately met following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities. Certain RAOs may never be met since groundwater flow through and leaching of constituents from residual soils would continue.	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following conversion of basements to crawl spaces in the 115 River Road building and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings if and as needed	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met prior to reaching the subaqueous reactive barrier.
6. Implementability					
(a) Technical feasibility	Feasible.	Solidification/stabilization is technically feasible based on site conditions, pending the results of bench- and pilot- testing. Implementation is feasible if large (>12") objects are removed from the surface and subsurface prior to solidification/stabilization. Additional support or alternative measure to protect stability of structures adjacent to high arsenic area will be needed during construction.	Feasible.	Feasible.	Use of subaqueous reactive barriers is technically feasible pending results of bench- and pilot-scale testing. Subaqueous reactive barriers are considered an innovative technology.

TABLE 5-2
Detailed Evaluation of Alternative 3—Containment, Excavation and In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(b) Administrative feasibility	<p>Administratively feasible, however, access to properties would be needed during construction activities.</p> <p>Rerouting of utilities would need to be coordinated with utility companies.</p>	<p>Impacts to nearby buildings would need to be avoided by measures such as rerouting traffic during construction activities and temporarily relocating the entrance to the hotel and stores near the high arsenic area.</p> <p>Administratively feasible, however, access is needed for mixing and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established.</p> <p>Rerouting of utilities would need to be coordinated with utility companies.</p>	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.	Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.

7. Total Cost

Total Present Worth Cost \$39,767,000 to \$85,215,000
Range*

* The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the FS, the SRI and/or during engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix C.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
NAPL non-aqueous phase liquid
NJDEP New Jersey Department of Environmental Protection
OU1 Operable Unit 1
OU2 Operable Unit 2
PRG preliminary remediation goal
RAO remedial action objective
TMV toxicity, mobility, or volume
VOC volatile organic compound

TABLE 5-3
Detailed Evaluation of Alternative 4—In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
Description of Remedy	In situ solidification/stabilization of tar boils, shallow NAPL present in NZ-1 and NZ-2, and deep NAPL present in NZ-5. Institutional controls would be established and maintained to document and limit use of areas with constituents remaining in place.	Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic liner and the liner would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with constituents remaining in place.	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	The basement in 115 River Road building would be converted to a crawl space with ventilation. Institutional controls would be established and maintained to control new construction and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and former Lever Brother properties, as needed.	Groundwater would be treated by a reactive subaqueous barrier prior to discharge to the Hudson River. Reactive material is encapsulated between carrier textiles and placed over the sediments in OU2. Institutional controls restricting groundwater use would be established.
1. Overall Protection of Human Health and the Environment					
	<p>The potential for exposure to the principal threat waste would be minimized through solidification/stabilization, capping, and institutional controls.</p> <p>Constituents remain in place; however, solidification/stabilization would be designed to significantly reduce leaching of constituents from treated soils under normal groundwater geochemical conditions.</p>	<p>Solidification/stabilization would prevent potential direct contact/ingestion risk.</p> <p>The principal threat risk of exposure to arsenic source materials would be minimized through solidification/stabilization and institutional controls.</p> <p>Constituents remain in place; however, solidification/stabilization would be designed to eliminate leaching of constituents under normal groundwater geochemical conditions.</p> <p>Shallow stabilization would minimize the infiltration rate; however, groundwater would continue to flow through affected soils, leaching constituents to groundwater.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or contact with contaminated subsurface soil.</p>	<p>Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil.</p> <p>Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.</p>	<p>Alternative would provide vapor barrier and limit access to 115 River Road basements, which reduces inhalation potential.</p> <p>Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements.</p> <p>Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings.</p> <p>Vapor mitigation systems would be installed, as needed, in existing buildings.</p>	<p>Reactive barrier treats or adsorbs groundwater constituents prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors.</p> <p>Institutional controls would restrict the use of the groundwater.</p>

TABLE 5-3
Detailed Evaluation of Alternative 4—In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
2. Compliance with ARARs					
	<p>Must meet substantive requirements for air pollution control using dust and vapor suppression and/or vapor collection.</p> <p>Design would address stormwater management and changed groundwater flow patterns.</p> <p>Complies with the ARAR to treat, remove, or contain NAPL by treating NAPL with solidification/stabilization.</p> <p>Under this alternative, NAPL outside the treatment zones would continue to leach constituents to groundwater and exceedances would persist indefinitely.</p>	<p>This alternative would comply with arsenic ARARs by mitigating the potential risks associated with ingestion or direct contact. In addition, leaching through the surface would be greatly reduced.</p> <p>Meets ARAR for controlling potential risk in soil by treating soil containing residual arsenic which reduces the exposure to constituents above the cleanup goal.</p> <p>Dust emissions from stabilization would be controlled as necessary to meet Clean Air Act ARARs.</p> <p>ARARs would be met because cap integrity would be maintained through regular inspections and repairs, and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	<p>ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	<p>The ARARs for vapor intrusion would be met as 115 River Road Building would undergo remedy to reduce potential vapor intrusion. 115 River Road and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.</p>	<p>The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria.</p> <p>Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.</p>
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	<p>Potential risks due to constituents left in place would be greatly reduced because infiltration and leaching would be greatly reduced. This would be verified and demonstrated by bench-and/or pilot-tests as well as by post-remedy testing of solidification/stabilization soils, as well as by periodic groundwater monitoring after soil mixing.</p> <p>The presence of monoliths resulting from solidification/stabilization would impact groundwater flow.</p>	<p>Potential risks due to constituents left in place would be greatly reduced because infiltration and leaching would be greatly reduced. This would be verified and demonstrated by bench-and/or pilot-tests, tests of solidified/stabilized soils, and periodic groundwater monitoring after soil mixing.</p> <p>The presence of monoliths resulting from solidification/stabilization would impact groundwater flow.</p> <p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls.</p> <p>Solidification/stabilization is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged.</p> <p>Leaching would diminish, although lateral infiltration and subsequent leaching would occur.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain.</p> <p>Potential risks would be controlled by new slabs in converted crawl spaces at 115 River Road and maintenance of institutional controls and vapor mitigation.</p> <p>Magnitude of potential risk in buildings would be maintained below appropriate standards.</p> <p>Chosen methods are proven technologies for vapor mitigation.</p>	<p>Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions.</p> <p>Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.</p>

TABLE 5-3

Detailed Evaluation of Alternative 4—In Situ Solidification/Stabilization
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(b) Adequacy and reliability of controls	Solidified soils and institutional controls are adequate and reliable in preventing direct contact and leaching but would require monitoring indefinitely.	Solidified soils and institutional controls are adequate and reliable in preventing direct contact but would require monitoring indefinitely.	Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Vapor mitigation would be reliable with proper maintenance and access restrictions. Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.	Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy. Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	NZ-1, NZ-2, NZ-5 and tar boil impacted soils would be solidified /stabilized in situ with reagents mixed in via large diameter augers.	Arsenic soils impacted over 336 ppm would be solidified/stabilized with reagents mixed in via large diameter augers.	No treatment used.	Vapor intrusion would be mitigated by the concrete slabs in the converted and ventilated crawl spaces in the 115 River Road building. Vapor intrusion mitigation would be applied to other buildings if and as needed.	Groundwater constituents would be treated/ adsorbed before discharging to surface water.
(b) Degree and quantity of TMV reduction	Mobility would be reduced but volume would not be reduced. Leaching of constituents to groundwater would be reduced.	Mobility would be reduced but volume would not be reduced. Leaching of constituents to groundwater would be reduced.	Toxicity and volume of residual soil constituents would remain. Mobility of residually impacted soils would be reduced through the maintenance of the cap, the liner and existing road surfaces; however, mobility via leaching to groundwater would continue.	Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Road basements. Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed. Toxicity, mobility, and volume of contamination in underlying soils would remain.	Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River.
(c) Irreversibility of TMV reduction	Solidification/stabilization process immobilizes NAPL in the soil matrix in situ to minimize/eliminate leaching potential. Bench- and pilot-scale testing would be completed to determine the irreversibility of the process. This would be verified by sampling and analysis of the solidified/stabilized soils and groundwater would be monitored after treatment.	Solidification/stabilization process immobilizes arsenic in the soil matrix in situ to minimize/ eliminate leaching potential. Bench- and pilot-scale testing would be completed to determine the irreversibility of the process. This would be verified by sampling and analysis of solidified/stabilized soils, and groundwater would be monitored after treatment.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed. Subaqueous reactive barrier treatment may be reversible if adsorption sites saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required.
(d) Type and quantity of treatment residuals	NAPLs stabilized in the soil matrix in-situ would remain on-site.	Arsenic stabilized in the soil matrix in situ would remain on site.	Impacted soils would remain on site but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin.
(e) Statutory preference for treatment	Would meet NJDEP preference for treatment of NAPLs in the areas treated.	Would meet NJDEP preference for treatment of arsenic in soil.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference met for groundwater because it would be treated before discharging to the river.

TABLE 5-3
Detailed Evaluation of Alternative 4—In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(f) Sustainability	<p>Effectively minimizes need for transportation and disposal of generated waste.</p> <p>High greenhouse gas emissions from mixing equipment but of limited duration and balanced by reduced truck traffic impacts.</p> <p>Unsustainable in that future land uses are restricted by treated wastes left in place.</p>	<p>Effectively minimizes need for transportation and disposal of generated waste.</p> <p>High greenhouse gas emissions from mixing equipment but of limited duration and balanced by reduced truck traffic impacts.</p> <p>Unsustainable in that future land uses are restricted by treated wastes left in place.</p>	<p>Effectively minimizes need for transportation and disposal of generated waste. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production and capping and would effectively reduce the volume of surface water runoff.</p> <p>Unsustainable in that future land uses are restricted by untreated wastes left in place</p>	<p>No significant impacts.</p> <p>Unsustainable in that future land uses are restricted by untreated wastes left in place</p>	<p>Energy efficient remedy using natural process rather than mechanical systems. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies.</p> <p>Unsustainable in that groundwater is not restored to drinking water quality</p>
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	<p>Implementation of NAPL and tar boil stabilization could result in the potential for additional risk to workers due to high concentrations of NAPL and COCs expected to be present in the shallow soils within the treatment areas.</p> <p>Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control).</p> <p>Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans.</p>	<p>Implementation of arsenic solidification/stabilization could result in additional potential risk to workers due to high concentrations of arsenic expected to be present in soils within the treatment areas.</p> <p>Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control).</p> <p>Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans.</p>	<p>Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.</p>	<p>Minimal potential risks to the environment during construction activities.</p>	<p>Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension.</p> <p>Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water.</p> <p>Potential temporary river habitat destruction during reactive barrier construction.</p>
(b) Protection of community during remedial action	<p>Potential risks to the community during solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls.</p> <p>Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor suppressing foam).</p>	<p>Potential risks to the community during solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls.</p> <p>Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor suppressing foam).</p>	<p>The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls.</p> <p>The RAO to prevent erosion would be immediately met following cap construction.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities.</p> <p>Certain RAOs may never be met since groundwater flow through and leaching of constituents from residual soils would continue.</p>	<p>The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following conversion of basements to crawl spaces in the 115 River Road building and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings if and as needed</p>	<p>The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier</p> <p>Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met prior to reaching the subaqueous reactive barrier.</p>

TABLE 5-3
Detailed Evaluation of Alternative 4—In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(c) Environmental impacts of remedial action	<p>Design would include stormwater management and management of new groundwater flow pathways.</p> <p>Site runoff during mixing would be controlled by using adequate erosion controls.</p> <p>Potential risks to the environment include generated vapors, noise, and odors during mixing. These potential risks would be mitigated during implementation through use of engineering controls.</p>	<p>Design would include storm water management and management of new groundwater flow pathways.</p> <p>Site runoff during mixing would be controlled by using appropriate erosion controls.</p> <p>Potential risks to the environment include generated vapors, noise, and odors during mixing. These potential risks would be mitigated during implementation through use of engineering controls.</p>	<p>Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.</p>	<p>Minimal potential risks to the environment during construction activities.</p>	<p>Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension.</p> <p>Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls would be developed to capture NAPL that may be released to surface water (such as containment booms).</p> <p>Potential temporary River habitat destruction during reactive barrier construction.</p>
(d) Time until RAOs are achieved	<p>The treatment of the NAPL through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping area complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than one year).</p> <p>RAOs would not be met in areas outside of the stabilized area.</p>	<p>The treatment of the arsenic through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping are complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than one year).</p>	<p>The RAOs to prevent unacceptable risk as a result of exposure to soils would be met following cap construction and establishment of institutional controls.</p> <p>The RAO to prevent erosion would be met following cap construction.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities.</p> <p>Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.</p>	<p>The RAO to prevent unacceptable risk as a result of exposure to vapors would be met following conversion of basements to crawl spaces in the 115 River Road building and installation of the ventilation systems and by performing in door air monitoring and the installation of vapor mitigation systems, if needed.</p>	<p>The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met by use of the in situ treatment.</p> <p>Establishment of the institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in groundwater on upgradient portions of the site would not be met.</p>
6. Implementability					
(a) Technical feasibility	<p>Solidification/stabilization is technically feasible based on site conditions, pending the results of bench and pilot testing.</p> <p>Implementation would be feasible if large (>12") objects are removed from the surface and subsurface prior to solidification/stabilization.</p> <p>Additional support or alternative measure to protect stability of structures adjacent to high arsenic area will be needed during construction.</p>	<p>Solidification/stabilization is technically feasible based on site conditions, pending the results of bench- and pilot- testing.</p> <p>Implementation is feasible if large (>12") objects are removed from the surface and subsurface prior to solidification/stabilization.</p> <p>Additional support or alternative measure to protect stability of structures adjacent to high arsenic area will be needed during construction.</p>	Feasible.	Feasible.	<p>Use of subaqueous reactive barriers is technically feasible pending results of bench- and pilot-scale testing.</p> <p>Subaqueous reactive barriers are considered an innovative technology.</p>

TABLE 5-3
Detailed Evaluation of Alternative 4—In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(b) Administrative feasibility	<p>Impacts to nearby buildings would need to be avoided by measures such as temporary parking and temporarily relocating the entrance of 115 River Road.</p> <p>Administratively feasible; however, access is needed for mixing and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established.</p> <p>Rerouting of utilities would need to be coordinated with utility companies.</p>	<p>Impacts to nearby buildings would need to be avoided by measures such as rerouting traffic during construction activities and temporarily relocating the entrance to the hotel and stores near the high arsenic area.</p> <p>Administratively feasible, however, access is needed for mixing and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established.</p> <p>Rerouting of utilities would need to be coordinated with utility companies.</p>	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.	Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials are readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.

7. Total Cost

Total present worth cost range* \$26,166,000 to \$56,070,000

* The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the FS, the SRI and/or during engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix C.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
NAPL non-aqueous phase liquid
NJDEP New Jersey Department of Environmental Protection
OU1 Operable Unit 1
OU2 Operable Unit 2
PRG preliminary remediation goal
RAO remedial action objective
TMV toxicity, mobility, or volume
VOC volatile organic compound

TABLE 5-4

Detailed Evaluation of Alternative 5—In Situ Solidification/Stabilization and In Situ Treatment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
Description of Remedy	Tar boils at the ground surface throughout the site, and NZ-1 and NZ-2 soils will be excavated to a depth of 4 ft bgs for off-site disposal. NAPL would be collected via 14 recovery wells located in NZ-1 and NZ-5 and two trenches located in NZ-2 near the Hudson River. NAPL collection would be followed by in situ chemical oxidation (ISCO) in NAPL zones NZ-1 and NZ-2, and in NZ-5. Injection points will be placed adjacent to 115 River Road, but not beneath it.	Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic liner and the liner would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with constituents remaining in place.	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	The basement in the 115 River Road building would be converted to a crawl space with ventilation. Institutional controls would be established and maintained to prevent vapor intrusion into new buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and Former Lever Brother properties, as needed.	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established.
1. Overall Protection of Human Health and the Environment					
	<p>In situ treatment with ISCO, shallow excavation and institutional controls would reduce contaminant mass and minimize exposure to principal threat waste I through direct contact, ingestion, and volatilization.</p> <p>ISCO will reduce contaminant mass that is leaching constituents from the soils to surface water or groundwater; however, constituents that do not come in contact with oxidant will remain and continue to leach to groundwater.</p>	<p>Solidification/stabilization would prevent potential direct contact/ingestion risk.</p> <p>The principal threat risk of exposure to arsenic source materials would be minimized through solidification/stabilization and institutional controls.</p> <p>Constituents remain in place; however, solidification/stabilization would be designed to eliminate leaching of constituents under normal groundwater geochemical conditions.</p> <p>Shallow stabilization would minimize the infiltration rate; however, groundwater would continue to flow through affected soils, leaching constituents to groundwater.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or contact with contaminated subsurface soil.</p>	<p>Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil.</p> <p>Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.</p>	<p>Alternative would provide vapor barrier and limit access to 115 River Road basements, which reduces inhalation potential.</p> <p>Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements.</p> <p>Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings.</p> <p>Vapor mitigation systems would be installed, as needed, in existing buildings.</p>	<p>Reactive barrier treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors.</p> <p>Institutional controls would restrict the use of the groundwater.</p>

TABLE 5-4
Detailed Evaluation of Alternative 5—In Situ Solidification/Stabilization and In Situ Treatment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
2. Compliance with ARARs					
	Complies with the ARAR to treat, remove, or contain NAPL by excavating or chemically oxidizing NAPL, to the extent practicable.	<p>This alternative would comply with arsenic ARARs by mitigating the potential risks associated with ingestion or direct contact. In addition, leaching through the surface would be greatly reduced.</p> <p>Meets ARAR for controlling potential risk in soil by treating soil containing residual arsenic which reduces the exposure to constituents above the cleanup goal.</p> <p>Dust emissions from stabilization would be controlled as necessary to meet Clean Air Act ARARs.</p> <p>ARARs would be met because cap integrity would be maintained through regular inspections and repairs, and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.</p>	ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	The ARARs for vapor intrusion would be met as 115 River Road Building would undergo remedy to reduce potential vapor intrusion. 115 River Road and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.	<p>The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria.</p> <p>Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.</p>
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	Potential risks due to constituents left in place would be reduced; however, some NAPL will remain and the heat generated during the oxidation reactions and transferred throughout the subsurface could mobilize some of this remaining NAPL.	<p>Potential risks due to constituents left in place would be greatly reduced because infiltration and leaching would be greatly reduced. This would be verified and demonstrated by bench- and/or pilot-tests, tests of solidified/stabilized soils, and periodic groundwater monitoring after soil mixing.</p> <p>The presence of monoliths resulting from solidification/stabilization would impact groundwater flow. Increased groundwater flow through untreated areas could mobilize constituents in those areas.</p> <p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls.</p> <p>Solidification/stabilization is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Potential risks due to constituents left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged.</p> <p>Leaching would diminish, although lateral infiltration and subsequent leaching would occur.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Potential risk related to potential subsurface volatilization of VOCs would remain.</p> <p>Potential risks would be controlled by new slabs in converted crawl spaces at 115 River Road and maintenance of institutional controls and vapor mitigation.</p> <p>Magnitude of potential risk in buildings would be maintained below appropriate standards.</p> <p>Chosen methods are proven technologies for vapor mitigation.</p>	<p>Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions.</p> <p>Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.</p>

TABLE 5-4

Detailed Evaluation of Alternative 5—In Situ Solidification/Stabilization and In Situ Treatment
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(b) Adequacy and reliability of controls	<p>Treatment of soils and institutional controls are adequate and reliable in preventing direct contact. Treatment of soils reduces leaching.</p> <p>Groundwater sampling would be required to monitor for rebound of constituents.</p>	<p>Solidified soils and institutional controls are adequate and reliable in preventing direct contact but would require monitoring indefinitely.</p>	<p>Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p> <p>Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.</p>	<p>Vapor mitigation would be reliable with proper maintenance and access restrictions.</p> <p>Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.</p>	<p>Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy.</p> <p>Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.</p>
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	<p>Excavated soil and recovered NAPL would be disposed of offsite.</p> <p>NZ-1, NZ-2, and NZ-5 would be treated with ISCO, reagent assumed to be Fenton's reagent.</p>	<p>Arsenic soils impacted over 336 ppm would be solidified/stabilized with reagents mixed in via large diameter augers.</p>	<p>No treatment used.</p>	<p>Vapor intrusion would be mitigated by the concrete slabs in the converted and ventilated crawl spaces in the 115 River Road building. Vapor intrusion mitigation would be applied to other buildings if and as needed.</p>	<p>Groundwater constituents would be treated/adsorbed before discharging to surface water.</p>
(b) Degree and quantity of TMV reduction	<p>Toxicity, mobility, and volume would be reduced by NAPL recovery.</p> <p>ISCO oxidizes the organic compounds that come in contact with the oxidant, which reduces toxicity, mobility, and volume.</p> <p>Pilot-scale testing would be completed to optimize dosages and determine the reduction in concentrations that can be achieved.</p>	<p>Mobility would be reduced but volume would not be reduced.</p> <p>Leaching of constituents to groundwater would be reduced.</p>	<p>Toxicity and volume of residual soil contamination would remain.</p> <p>Mobility of residually impacted soils would be reduced through the maintenance of the cap, the liner and existing road surfaces; however, mobility via leaching to groundwater would continue.</p>	<p>Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Road basements.</p> <p>Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed.</p> <p>Toxicity, mobility, and volume of contamination in underlying soils would remain.</p>	<p>Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River.</p>
(c) Irreversibility of TMV reduction	<p>NAPL recovery and destruction of the organics through ISCO are irreversible.</p>	<p>Solidification/stabilization process immobilizes arsenic in the soil matrix in situ to minimize/eliminate leaching potential.</p> <p>Bench- and pilot-scale testing would be completed to determine the irreversibility of the process. This would be verified by sampling and analysis of solidified/stabilized soils, and groundwater would be monitored after treatment.</p>	<p>Reversible if institutional controls and cap were not maintained.</p>	<p>Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.</p>	<p>Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed.</p> <p>Subaqueous reactive barrier treatment may be reversible if adsorption sites saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required.</p>
(d) Type and quantity of treatment residuals	<p>Extracted NAPL is estimated to be 1,000 gallons per year</p>	<p>Arsenic stabilized in the soil matrix in situ would remain on site.</p>	<p>Impacted soils would remain on site but access and infiltration would be controlled.</p>	<p>Source of vapors would remain in the subsurface.</p>	<p>Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin.</p>
(e) Statutory preference for treatment	<p>Would meet NJDEP preference for treatment of NAPLs in the areas treated.</p>	<p>Would meet NJDEP preference for treatment of arsenic in soil.</p>	<p>Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.</p>	<p>Preference would be met for vapor because it would be kept out of occupied buildings.</p>	<p>Preference met for groundwater because it would be treated before discharging to the river.</p>

TABLE 5-4

Detailed Evaluation of Alternative 5—In Situ Solidification/Stabilization and In Situ Treatment
 Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(f) Sustainability	<p>High green house gas emissions from excavation equipment, waste transportation and transportation of clean fill to the site.</p> <p>Significant waste generated which would require off-site disposal. Moving waste from one place to another is not considered sustainable.</p> <p>ISCO is a more sustainable process because it is not highly energy intensive.</p>	<p>Effectively minimizes need for transportation and disposal of generated waste.</p> <p>High greenhouse gas emissions from mixing equipment but of limited duration and balanced by reduced truck traffic impacts.</p> <p>Unsustainable in that future land uses are restricted by treated wastes left in place.</p>	<p>Effectively minimizes need for transportation and disposal of generated waste. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production and capping and would effectively reduce the volume of surface water runoff.</p> <p>Unsustainable in that future land uses are restricted by untreated wastes left in place</p>	<p>No significant impacts.</p> <p>Unsustainable in that future land uses are restricted by untreated wastes left in place</p>	<p>Energy efficient remedy using natural process rather than mechanical systems. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies.</p> <p>Unsustainable in that groundwater is not restored to drinking water quality</p>
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	<p>Implementation of shallow NAPL and tar boil excavation could result in the potential for additional risk to workers due to NAPL and high concentrations of COCs.</p> <p>Implementation of ISCO could result in the potential for additional risk to workers, due to handling of large quantities of chemical required for oxidants.</p> <p>Potential risk to workers during remediation construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, noise control).</p>	<p>Implementation of arsenic solidification/stabilization could result in the potential for additional risk to workers due to high concentrations of arsenic expected to be present in soils within the treatment areas.</p> <p>Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control).</p> <p>Use of heavy equipment potentially exposes workers to additional safety risks and would be mitigated by health and safety plans.</p>	<p>Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).</p>	<p>Minimal potential risk to workers during construction of subslab and installation of vapor mitigation in basement.</p>	<p>Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.</p>
(b) Protection of community during remedial action	<p>Potential risks to the community during remediation construction include generated vapors, dust, noise, and odor during excavation. These potential risks would be mitigated during implementation through use of engineering controls.</p> <p>Heat generated during the oxidation reaction could result in increased NAPL mobility and volatility of constituents that could migrate to 115 River Road or other buildings via preferential pathways.</p>	<p>Potential risks to the community during solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risks to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls.</p> <p>Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor suppressing foam).</p>	<p>Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor suppressing foam).</p>	<p>Best management practices would be used during construction of the subslabs.</p>	<p>Minimal potential risks to the community during construction of the subaqueous reactive barrier. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.</p> <p>Engineering controls would be utilized to protect community from noise.</p>
(c) Environmental impacts of remedial action	<p>Design would include stormwater management.</p> <p>Heat generated during the oxidation reaction could result in increased mobility and volatility of the residual NAPL.</p> <p>Potential risks to the environment include generated dust, vapors, noise, and odors during excavation and ISCO. These potential risks would be mitigated during implementation through use of engineering controls.</p>	<p>Design would include storm water management and management of new groundwater flow pathways.</p> <p>Site runoff during mixing would be controlled by using appropriate erosion controls.</p> <p>Potential risks to the environment include generated vapors, noise, and odors during mixing. These potential risks would be mitigated during implementation through use of engineering controls.</p>	<p>Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.</p>	<p>Minimal potential risks to the environment during construction activities.</p>	<p>Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension.</p> <p>Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water.</p> <p>Potential temporary river habitat destruction during reactive barrier construction.</p>

TABLE 5-4

Detailed Evaluation of Alternative 5—In Situ Solidification/Stabilization and In Situ Treatment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
(d) Time until RAOs are achieved	<p>Anticipated NAPL recovery would be completed in an estimated 5-10 years to reduce mass in the subsurface before ISCO is implemented.</p> <p>Oxidation reaction is instantaneous; however, multiple injections events are typically needed.</p> <p>The RAOs to prevent unacceptable risk as a result of exposure to soils would be met following in situ treatment and establishment of institutional controls in the areas treated. RAOs would not be met in areas outside of the treatment areas.</p>	<p>The treatment of the arsenic through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping are complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than one year).</p>	<p>The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls.</p> <p>The RAO to prevent erosion would be immediately met following cap construction.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities.</p> <p>Certain RAOs may never be met since groundwater flow through and leaching of constituents from residual soils would continue.</p>	<p>The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following conversion of basements to crawl spaces in the 115 River Road building and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings if and as needed</p>	<p>The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier</p> <p>Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met prior to reaching the subaqueous reactive barrier.</p>
6. Implementability					
(a) Technical feasibility	<p>ISCO would be technically feasible based on site conditions, pending the results of bench- and pilot-scale testing.</p>	<p>Solidification/stabilization is technically feasible based on site conditions, pending the results of bench- and pilot- testing.</p> <p>Implementation is feasible if large (>12") objects are removed from the surface and subsurface prior to solidification/stabilization.</p> <p>May need to provide additional support for structures in high arsenic area.</p>	<p>Feasible.</p>	<p>Feasible.</p>	<p>Use of subaqueous reactive barriers is technically feasible pending results of bench- and pilot-scale testing.</p> <p>Subaqueous reactive barriers are considered an innovative technology.</p>
(b) Administrative feasibility	<p>Impacts to nearby buildings would need to be avoided by measures such as rerouting traffic during remedial activities.</p>	<p>Impacts to nearby buildings would need to be avoided by measures such as rerouting traffic during construction activities and temporarily relocating the entrance to the hotel and stores near the high arsenic area.</p> <p>Administratively feasible, however, access is needed for mixing and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established.</p> <p>Rerouting of utilities would need to be coordinated with utility companies.</p>	<p>Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.</p>	<p>Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.</p>	<p>Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.</p>
(c) Availability of services and materials	<p>Necessary engineering services and materials are readily available for installation and operation.</p>	<p>Necessary engineering services and materials readily available for installation and operation.</p>	<p>Necessary engineering services and materials readily available for installation and operation.</p>	<p>Necessary engineering services and materials readily available for installation and operation.</p>	<p>Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.</p>

TABLE 5-4
Detailed Evaluation of Alternative 5—In Situ Solidification/Stabilization and In Situ Treatment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soils	Vapor	Groundwater/Surface Water
7. Total Cost					
Total present worth cost range*	\$55,986,000 to \$ 119,970,000				

* The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the FS, the SRI and/or during engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix C.

ARAR applicable or relevant and appropriate requirement

COC constituent of concern

NAPL non-aqueous phase liquid

"NJDEP New Jersey Department of Environmental Protection

OU1 Operable Unit 1

OU2 Operable Unit 2

PRG preliminary remediation goal

RAO remedial action objective

TMV toxicity, mobility, or volume

VOC volatile organic compound

TABLE 5-5
Detailed Evaluation of Alternative 6—Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
Description of Remedy	NAPL zones (NZ-1, NZ-2, and NZ-5) and tar boils would be excavated and disposed of off-site. River Road and Gorge Road would be temporarily diverted during excavation. Excavation would require dewatering to achieve depths greater than 4 feet. Following excavation the site would be filled with clean material to grade. NAPL would be separated from the water generated from dewatering activities. NAPL would be disposed of off-site and water would be treated on site prior to discharge to the Hudson River.	Areas with arsenic concentrations greater than 336 ppm would be excavated, including material beneath the existing liner, and disposed of off-site. Excavations to depths greater than 4 ft below ground surface would require dewatering. The access ramp to the building at the Edgewater property would be demolished in advance of excavation. Water generated from dewatering activities would be treated on site prior to discharge to the Hudson River.	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	The basement in the 115 River Road building would be converted to a crawl space with ventilation. Institutional controls would be established and maintained to prevent vapor intrusion into new buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and Former Lever Brother properties, as needed.	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established.
1. Overall Protection of Human Health and the Environment					
	NAPL zones (NZ-1, NZ-2, and NZ-5) soils and tar boils posing potential risk above acceptable levels would be removed.	Soils containing arsenic that pose a potential risk above acceptable levels would be removed.	<p>Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils.</p> <p>Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil.</p> <p>Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.</p>	<p>Alternative would provide vapor barrier and limit access to 115 River Road basements, which reduces inhalation potential.</p> <p>Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements.</p> <p>Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings.</p> <p>Vapor mitigation systems would be installed, as needed, in existing buildings.</p>	<p>Reactive barrier treats or adsorbs groundwater constituents prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors.</p> <p>Institutional controls would restrict the use of the groundwater.</p>
2. Compliance with ARARs					
	<p>Must meet substantive requirements for air pollution control using dust and vapor suppression and vapor collection.</p> <p>Engineering controls such as silt curtains with booms would provide protection to the Hudson River during construction activities.</p> <p>Meets ARAR for controlling potential risk in soil by removing, treating, or containing soil containing NAPL.</p> <p>Transportation and disposal of excavated material would be performed in accordance with applicable federal, state, and local regulations.</p>	<p>Must meet substantive requirements for air pollution control using dust and vapor suppression and vapor collection.</p> <p>Engineering controls such as silt curtains with booms would provide protection to the Hudson River during construction activities.</p> <p>Meets ARAR for controlling potential risk in soil by removing, treating, or containing soil containing arsenic.</p> <p>Transportation and disposal of excavated material would be performed in accordance with applicable federal, state, and local regulations.</p>	ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	The ARARs for vapor intrusion would be met as 115 River Road Building would undergo remedy to reduce potential vapor intrusion. 115 River Road and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.	<p>The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria.</p> <p>Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.</p>

TABLE 5-5
Detailed Evaluation of Alternative 6—Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	Once excavation is completed, residual risks would remain in soils not excavated. Constituents left in place beneath the excavation depths would be covered by clean backfill.	Once excavation is completed, residual risks would be largely eliminated. Constituents left in place beneath the excavation depths would be covered by clean backfill.	<p>Potential risks due to Constituents left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged.</p> <p>Leaching would diminish, although lateral infiltration and subsequent leaching would occur.</p> <p>Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.</p>	<p>Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Potential risk related to potential subsurface volatilization of VOCs would remain.</p> <p>Potential risks would be controlled by new slabs in converted crawl spaces at 115 River Road and maintenance of institutional controls and vapor mitigation.</p> <p>Magnitude of potential risk in buildings would be maintained below appropriate standards.</p> <p>Chosen methods are proven technologies for vapor mitigation.</p>	<p>Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions.</p> <p>Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.</p>
(b) Adequacy and reliability of controls	Excavation and institutional controls would be very reliable.	Excavation and institutional controls would be very reliable.	<p>Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.</p> <p>Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.</p>	<p>Vapor mitigation would be reliable with proper maintenance and access restrictions.</p> <p>Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.</p>	<p>Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy.</p> <p>Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.</p>
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	Excavated soils would be stabilized prior to disposal off-site, as necessary, to meet land disposal requirements.	Excavated soils would be stabilized prior to disposal off-site, as necessary, to meet land disposal requirements.	No treatment used.	Vapor intrusion would be mitigated by the concrete slabs in the converted and ventilated crawl spaces in the 115 River Road building. Vapor intrusion mitigation would be applied to other buildings if and as needed.	Groundwater constituents would be treated/ adsorbed before discharging to surface water.
(b) Degree and quantity of TMV reduction	<p>Toxicity, volume and mobility of NAPL would be reduced by removal of impacted soils.</p> <p>Soils removed during excavation would be stabilized prior to disposal, as necessary, to meet land disposal requirements.</p>	<p>Toxicity, volume and mobility all would be reduced by removal of impacted soils.</p> <p>Soils removed during excavation would be treated prior to disposal, as necessary, to meet land disposal requirements.</p>	<p>Toxicity and volume of residual soil contamination would remain.</p> <p>Mobility of residually impacted soils would be reduced through the maintenance of the cap, the liner and existing road surfaces; however, mobility via leaching to groundwater would continue.</p>	<p>Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Road basements.</p> <p>Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed.</p> <p>Toxicity, mobility, and volume of contamination in underlying soils would remain.</p>	Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River.

TABLE 5-5
Detailed Evaluation of Alternative 6—Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(c) Irreversibility of TMV reduction	Excavation of soils is irreversible; however, soils must be disposed offsite.	Excavation of soils is irreversible; however, soils must be disposed offsite.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed. Subaqueous reactive barrier treatment may be reversible if adsorption sites saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required.
(d) Type and quantity of treatment residuals	This alternative would result in approximately 166,000 cubic yards of treated soils to be disposed offsite.	This alternative would result in approximately 39,000 cubic yards of treated soils to be disposed offsite.	Impacted soils would remain on site but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin.
(e) Statutory preference for treatment	Preference would be met for excavated soils containing NAPL.	Preference would be met for excavated soils containing arsenic.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference met for groundwater because it would be treated before discharging to the river.
(f) Sustainability	High energy use and greenhouse gas emissions from excavation equipment, waste transportation and transportation of clean fill to the site. Significant waste generated which would require off-site disposal, which is considered unsustainable.	High energy use and greenhouse gas emissions from excavation equipment, waste transportation and transportation of clean fill to the site. Significant waste generated which would require off-site disposal, which is considered unsustainable.	Effectively minimizes need for transportation and disposal of generated waste. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production and capping and would effectively reduce the volume of surface water runoff. Unsustainable in that future land uses are restricted by untreated wastes left in place	No significant impacts. Unsustainable in that future land uses are restricted by untreated wastes left in place	Energy efficient remedy using natural process rather than mechanical systems. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies. Unsustainable in that groundwater is not restored to drinking water quality
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	Excavation of tar and NAPL and related activities would result in additional potential risk to workers, due to the presence of NAPL and high levels of COCs. Potential risk to workers during remediation would be mitigated by adherence to site-specific health and safety plan and engineering controls (e.g., dust suppression, odor control).	Excavation of arsenic areas would result in additional potential risk to workers, due to the presence of high concentrations of arsenic. Potential risk to workers during remediation would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during construction of subslab and installation of vapor mitigation in basement.	Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.

TABLE 5-5
Detailed Evaluation of Alternative 6—Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(b) Protection of community during remedial action	<p>There is the potential for air emissions and airborne particulate dispersion during excavation. Dust suppression and air monitoring would need to be performed during excavation to control potential emissions and protect the community.</p> <p>Active odor control would be required for excavations in NAPL-impacted areas due to the low odor threshold of the waste. Noise control may be needed.</p> <p>Safety-related risks to the community are associated with the truck traffic to remove excavated soil and building demolition debris.</p> <p>Stability of sidewalks, roads, and parking lots to be evaluated to determine safe excavation depth of fill material adjacent to these areas.</p> <p>Potential risks to the community during remedial construction include generated vapors and odor during excavation as well as safety risk to pedestrians walking near deep excavated areas. These potential risks would be mitigated during implementation through use of engineering controls.</p>	<p>There is the potential for air emissions and airborne particulate dispersion during excavation. Dust suppression and air monitoring would need to be performed during excavation to control potential emissions and protect the community.</p> <p>Engineering controls would be utilized to protect community from dust, vapors, and noise.</p> <p>Safety-related risks to the community are associated with the truck traffic to remove excavated soil.</p> <p>Stability of building on Edgewater to be evaluated to determine safe excavation depth of fill material adjacent the building.</p> <p>Potential risks to the community during remedial construction include generated vapors and odor during excavation as well as safety risk to pedestrians walking near deep excavated area adjacent to the building on Edgewater. These potential risks would be mitigated during implementation through use of engineering controls.</p>	<p>Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor suppressing foam).</p>	<p>Best management practices would be used during construction of the subslabs.</p>	<p>Minimal potential risks to the community during construction of the subaqueous reactive barrier. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.</p> <p>Engineering controls would be utilized to protect community from noise.</p>
(c) Environmental impacts of remedial action	<p>Could have significant impacts to the environment when removing large volumes of impacted soils on properties adjacent to the Hudson River. Significant active vapor control would be required at all excavations, along with covering stockpiles and controlling dust.</p> <p>Mobilization of NAPL during excavation would result in unknown impacts to the environment since the degree of mobilization and the flow directions are unknown. Similarly, dewatering for the purposes of excavation below the water table may mobilize NAPL. These potential risks would be addressed by monitoring and engineering controls.</p>	<p>Minimal potential risks to the environment during excavation assuming implementation of adequate monitoring and engineering controls.</p>	<p>Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.</p>	<p>Minimal potential risks to the environment during construction activities.</p>	<p>Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension.</p> <p>Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water.</p> <p>Potential temporary river habitat destruction during reactive barrier construction.</p>

TABLE 5-5
Detailed Evaluation of Alternative 6—Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
(d) Time until RAOs are achieved	The RAOs to minimize potential exposure through contact, ingestion, and inhalation are achieved as soon as excavation and backfilling are complete and institutional controls are in place.	The RAOs to minimize potential exposure through contact, ingestion, and inhalation are achieved as soon as excavation and backfilling are complete and institutional controls are in place.	<p>The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls.</p> <p>The RAO to prevent erosion would be immediately met following cap construction.</p> <p>Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities.</p> <p>Certain RAOs may never be met since groundwater flow through and leaching of constituents from residual soils would continue.</p>	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following conversion of basements to crawl spaces in the 115 River Road building and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings if and as needed	<p>The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier</p> <p>Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met prior to reaching the subaqueous reactive barrier.</p>
6. Implementability					
(a) Technical feasibility	Excavation is feasible; however, excavation near structures and utilities would have to be evaluated and structural support provided as needed.	Excavation is feasible; however, excavation near structures would have to be evaluated. Temporary access ramp would need to be provided	Feasible.	Feasible.	<p>Use of subaqueous reactive barriers is technically feasible pending results of bench- and pilot-scale testing.</p> <p>Subaqueous reactive barriers are considered an innovative technology.</p>
(b) Administrative feasibility	<p>Administratively feasible, however, access to properties would be needed for excavation.</p> <p>Rerouting of driveways and utilities would need to be coordinated with utility companies, property owners, and others.</p>	<p>Administratively feasible, however, access to properties would be needed for excavation.</p> <p>Rerouting of utilities would need to be coordinated with utility companies, property owners and others.</p> <p>Access to Edgewater property would need to be rerouted.</p>	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.	Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.

TABLE 5-5
Detailed Evaluation of Alternative 6—Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL-Contaminated Soil	Arsenic-Contaminated Soil	Residual Soil	Vapor	Groundwater/Surface Water
7. Total Cost					
Total present worth cost range*	\$67,557,000 to \$144,765,000				

* The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the FS, the SRI and/or during engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix C.

- ARAR applicable or relevant and appropriate requirement
- COC constituent of concern
- NAPL non-aqueous phase liquid
- NJDEP New Jersey Department of Environmental Protection
- OU1 Operable Unit 1
- OU2 Operable Unit 2
- PRG preliminary remediation goal
- RAO remedial action objective
- TMV toxicity, mobility, or volume
- VOC volatile organic compound

TABLE 5-6
Balancing Criteria Screening for Remedial Alternatives
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Balancing Criteria	Alternative				
	2—Containment	3—Containment, Excavation, and In Situ Solidification/Stabilization	4—In Situ Solidification/Stabilization	5—In Situ Solidification/Stabilization and Other In Situ Treatment	6—Excavation
1. Long-term effectiveness and permanence	1	4	6	6	4
2. Reduction of toxicity, mobility, and volume through treatment	1	4	8	8	4
3. Short-term effectiveness	10	6	6	4	1
4. Implementability	4	4	6	1	1
Total score without cost	16	18	26	19	10
5. Cost	8	6	8	4	1
Total score with cost^a	24	24	34	23	11

Note: The rankings used for this comparative analysis were determined based on the definitions provided below. The definitions are intended to provide a point of reference to the relative ranking selected.

^aBalancing criteria were weighted equally for the scoring; however, cost was shown for discussion purposes.

Scoring Definitions	Scoring									
	<div> <div>Best</div> <div>←</div> <div>→</div> <div>Worst</div> </div>									
	10	9	8	7	6	5	4	3	2	1
1) Long-term effectiveness and permanence	No residual risk remaining from untreated waste or treatment residual; therefore, no long-term residual management controls are required.			—	Low residual risk remaining from untreated waste or treatment residual and high long-term reliability and degree of confidence in residual management controls.			—	Low long-term reliability and degree of confidence in residual management controls and significant risk if controls fail.	
2) Reduction of toxicity, mobility, and volume through treatment	Technology permanently and significantly reduces TMV of principal threats at the site including mass destruction of contaminants.			—	Technology permanently and significantly reduces TMV of principal threats at the site including nondestructive treatment of contaminants.			—	TMV would remain and exposure pathways would be mitigated.	
3) Short-term effectiveness	Low risk to the community, workers, and environment during construction and implementation.			—	High risk to the community, workers, or environment during construction and implementation that would be mitigated through engineering or administrative controls			—	High risk to the community, workers, and environment during construction and implementation that would be mitigated through engineering or administrative controls	
4) Implementability	Low anticipated number of difficulties or uncertainties associated with the construction, standard equipment or services are used, and technologies are readily available for full-scale use.			—	Higher anticipated number of difficulties or uncertainties associated with the construction that may lead to schedule delays, may require specialize equipment or services, or limited vendor availability.			—	Highest anticipated number of difficulties or uncertainties associated with the construction that may lead to schedule delays, may require specialize equipment or services, and limited vendor availability.	
5) Cost (\$millions)	< 20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100

Compliance with ARARs

ARARs are cleanup standards, standards of control, and other substantive environmental statutes or regulations which are either “applicable” or “relevant and appropriate” to the CERCLA cleanup action (42 USC 9621 [d] [2]). ARARs are listed in Appendix A of this report. Applicable requirements directly address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site. Relevant and appropriate requirements are those that, while not applicable, address problems or situations sufficiently similar to those encountered at the CERCLA site such that the use of such a requirement is well suited to address the environmental or technical factors that are present at a particular site. The assessment against this criterion describes how the alternative complies with ARARs or presents the rationale for waiving an ARAR. ARARs can be grouped into three categories:

- **Chemical-specific:** ARARs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, establish the amount or concentration of a chemical that may remain in or be discharged to the environment.
- **Location-specific:** ARARs restrict the concentration of hazardous substances or the conduct of activities solely because they are in specific locations, such as flood-plains, wetlands, historic places, and sensitive ecosystems or habitats.
- **Action-specific:** ARARs include technology- or activity-based requirements that set controls or restrictions on design performance of remedial actions or management of hazardous constituents.

As described in Section 2.5, TI evaluations may be conducted in order to seek waiver of specific ARARs when site-specific conditions make it infeasible to achieve those ARARs within a reasonable timeframe.

5.1.2 Balancing Criteria

The five criteria listed below are used to weigh the tradeoffs between alternatives. The performance of each of the alternatives against the balancing criteria is evaluated in Tables 5-1 through 5-5.

Long-Term Effectiveness and Permanence

This criterion reflects CERCLA’s emphasis on implementing remedies that will ensure protection of human health and the environment in the long term as well as in the short term. The assessment of alternatives against this criterion evaluates the potential risk of residual concentrations of COCs at a site after completing a remedial action or enacting an NFA alternative and includes evaluation of the adequacy and reliability of controls.

Reduction of TMV Through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies. The criterion is specific to evaluating only how treatment reduces TMV and does not address containment actions such as capping.

Short-Term Effectiveness

This criterion addresses short-term impacts of the alternatives. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment (i.e., minimizing potential risks associated with an alternative) during the construction and implementation of a remedy until the response objectives have been met.

Implementability

The assessment against this criterion evaluates the technical and administrative feasibility of the alternative and the availability of the goods and services needed to implement it.

Cost

Cost encompasses all engineering, construction, and operations and maintenance and monitoring costs incurred over the life of the project. The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is a method of evaluating expenditures such as construction and operations and maintenance that occur over different lengths of time. This allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. The present worth of a project represents the amount of money, which if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. As stated in the RI/FS guidance (EPA, 1988a), these estimated costs are expected to provide an accuracy of plus 50 percent to minus 30 percent. The range applies only to the alternatives as they are defined in Section 4 and Appendix C and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is not intended to limit flexibility during remedial design, but to provide a basis for preparing cost estimates. Appendix C provides a breakdown of the cost estimate for each of the alternatives.

The cost estimates presented have been developed strictly for comparing the alternatives. The final costs of the project and the resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, the implementation schedule, the firm selected for final engineering design, and other variables. Therefore, final project costs will vary from the cost estimates. Because of these factors, project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established.

5.2 Detailed Analysis of Alternatives

The level of detail required to analyze each alternative against these evaluation criteria depends on the nature and complexity of the site, the types of technologies and alternatives being considered, and other project-specific considerations. The analysis is conducted in sufficient detail to understand the significant aspects of each alternative and to identify the uncertainties associated with the evaluation.

5.2.1 Detailed Analysis

The following six alternatives were developed and described in Section 4 for media in OU1:

- Alternative 1—NFA
- Alternative 2—Containment
- Alternative 3—Excavation, containment, and in situ solidification/stabilization
- Alternative 4—In situ solidification/stabilization
- Alternative 5—In situ solidification/stabilization and other in situ treatment
- Alternative 6—Excavation and offsite disposal

These alternatives were evaluated in detail using the seven evaluation criteria described in Section 5.1. The detailed evaluations for these soil media alternatives are presented in Tables 5-1 through 5-5.

5.2.2 Principal Threat Analysis

In Section 1.10, five areas were determined to pose a principal threat at OU1: NZ-1, NZ-2, NZ-5, tar boils, and the HCAA on the Quanta and Block 93 North properties. Table 4-1 provides a summary of actions that would be taken for each active alternative to address these principal threats.

NAPL Zone 1—Toxicity Potential

Alternatives 2 and 3 eliminate the direct contact exposure pathway at NZ-1 through capping and institutional controls, and the extraction of recoverable free-phase NAPL. Alternative 3 would also include the excavation of shallow soil within the footprint of NZ-1 (not including soil beneath 115 River Road). Alternatives 4 and 5 incorporate the use of innovative in situ technologies. Alternative 4 would mitigate potential risk through in situ solidification/stabilization, and Alternative 5 would utilize in situ chemical treatment following shallow excavation and free-phase NAPL recovery. Alternative 6 mitigates potential risk at NZ-1 through the physical removal of principal threat waste (not including soil beneath 115 River Road). All alternatives (except Alternative 1) would include the same vapor intrusion mitigation measures.

NAPL Zone 2—Mobility and Toxicity Potential

Mobility potential at NZ-2 is addressed in Alternatives 2 and 3 through the use of permeable barriers to NAPL migration (either a funnel-and-gate system or a PRB) in conjunction with free-phase NAPL recovery. In situ solidification/stabilization would be implemented in Alternative 4 to physically bind the NAPL within a stabilized mass, reducing the ability of the material to flow, solubilize, or volatilize. Alternative 5 combines shallow excavation and NAPL recovery with in situ treatment. Alternative 6 eliminates the potential for migration by physically removing NZ-2 for offsite disposal.

Alternatives 2 and 3 eliminate the direct contact exposure pathway at NZ-2 through capping and institutional controls. Alternative 3 would also include the excavation of shallow soil (to 4 feet bgs). Alternatives 4 and 5 incorporate the use of in situ technologies—solidification/stabilization in Alternative 4 and in situ chemical treatment in Alternative 5. Alternative 5 would also include shallow excavation and free-phase NAPL recovery. Alternative 6 mitigates potential risk at NZ-2 through the physical removal of source material from the zone.

NAPL Zone 5—Mobility and Toxicity Potential

Both potential migration and potential exposure of ecological receptors at OU2 to NAPL in NZ-5 are mitigated in Alternatives 2 and 3 through the use of either a funnel-and-gate or PRB system and NAPL recovery. Additionally, Alternative 3 includes shallow excavation. Potential migration and ecological toxicity is reduced through in situ solidification/stabilization in Alternative 4, and by NAPL recovery, excavation, and in situ treatment in Alternative 5. Alternative 6 eliminates the potential for migration or exposure through the physical removal and offsite disposal of material containing NAPL.

Tar Boils—Toxicity Potential

NAPL extraction would be used in Alternative 2 to minimize the formation of tar boils, and capping and institutional controls would reduce the potential risk of direct contact. In Alternatives 3 and 5, shallow excavation would be used in conjunction with NAPL recovery and capping to limit the formation of tar boils and restrict direct contact. In Alternative 4, in situ solidification/stabilization would prevent the formation of tar boils by immobilizing the NAPL, and in Alternative 6, material where tar boils have been observed would be excavated and disposed offsite.

HCAA (Quanta and Block 93 North)—Toxicity Potential

In Alternative 2, the direct contact exposure pathway is eliminated through the implementation of capping and institutional controls. Alternatives 3, 4, and 5 would include the in situ solidification/stabilization of the HCAA, sequestering COCs in place. Alternative 6 would mitigate the potential risk of direct contact with arsenic source material through excavation and offsite disposal.

5.2.3 Comparative Analysis

EPA's stated program goals and expectations have been carefully considered in developing a range of remedial alternatives for the site. Consideration has been given to identifying appropriate remedial approaches to address source materials that may constitute a principal threat based on toxicity and mobility in accordance with EPA guidance (EPA, 1991), as well as mitigating potential risks posed by low level threat source material or residual COCs. Consideration has also been given to the applicability of innovative, emerging, and sustainable source reduction technologies in meeting these goals and expectations. The alternatives are evaluated against the threshold and balancing criteria as discussed in the following subsections.

Overall Protection of Human Health and the Environment

The No Further Action alternative is not protective. The remaining alternatives are protective. The considered alternatives prevent unacceptable human health and ecological risk by eliminating exposure pathways through treatment, removal, or containment of both source material and media containing residual concentrations of COCs. Each active alternative includes capping of areas not otherwise treated or contained. Each alternative also includes institutional controls to prevent exposure to contaminated soil and groundwater.

Leaching of COCs from soil or source material to groundwater would continue for all alternatives, since COCs posing no risk to receptors would remain in place for all alternatives (e.g. deep residual NAPL). However, active alternatives include some degree of source removal and/or in situ treatment components that would reduce leaching from source materials in some portions of the site. Alternative 2 includes NAPL recovery, Alternatives 3, 4, and 5 would reduce leaching from the HCAA on both the Quanta and former Celotex properties by solidifying/stabilizing arsenic source materials in these areas in situ. Alternatives 3, 4, and 5 also incorporate technologies to reduce leaching from NAPL source material, through solidification/stabilization and NAPL recovery with in situ chemical treatment, respectively. Alternative 6 includes extensive soil excavation and off-site disposal.

Potential migration of free-phase NAPL in NZ-2 and NZ-5 would be mitigated in each alternative. Alternatives 2 and 3 would include a funnel-and-gate or PRB to physically restrict migration. Alternative 4 would include the solidification/stabilization of these NAPL zones, while Alternative 5 would rely on NAPL recovery, and in situ chemical treatment. Principal threat waste near the shoreline would be excavated and disposed offsite in Alternative 6.

Short-term risks during implementation would need to be mitigated for each alternative through health and safety plans and engineering controls. These controls would be most complicated in Alternatives 5 and 6. Alternative 5 poses the potential risk of NAPL mobilization and significant vapor generation during implementation of in situ chemical treatment. The large excavations required in Alternative 6 would require air monitoring and controls to protect the community from vapor generated by exposed soil containing NAPL, as well as emissions from increased truck traffic and noise.

All alternatives except the No Further Action alternative include the same actions to prevent migration of dissolved phase COCs to OU2 and to address the potential risk of vapor intrusion.

Compliance with ARARs

Appendix B presents a compilation of all the State and Federal chemical-specific, location-specific, and action-specific ARARs considered for OU1. With the exception of the NFA alternative, each alternative satisfies the ARARs, except where it is technically impracticable to do so. Some principal threat and low level threat source material will be left behind because of technological limitations or site-specific conditions. Therefore, technical impracticability is being evaluated as part of a separate document supporting the issuance of a Technical Impracticability Waiver for certain ARARs, particularly the reduction of COC concentrations in groundwater to drinking water levels. The waiver will specify which ARARs cannot be achieved. For all alternatives except the NFA alternative, exposure to media not meeting ARARs would be prevented, thereby eliminating potential risk.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of alternatives vary largely as a result of the adequacy and reliability of the systems implemented. While Alternative 6 appears to offer a comparatively higher degree of long-term effectiveness at this site because most principal threat waste would be physically removed, leaching from source material left behind would

remain a potential risk similar to the other alternatives. In addition, the material would be placed at a different location, potentially causing problems there eventually.

The in situ solidification/stabilization used in Alternatives 3, 4 and 5 is considered effective over the long term, and assurance would be ascertained through bench and pilot testing prior to remedy implementation, performance testing during implementation, and long-term monitoring after implementation. This technology would not remove the contaminants but would immobilize them permanently on site. This technology would effectively and permanently sequester principal threat waste to reduce the potential for this material to represent a source of COCs to groundwater and air.

Alternatives 3 and 5 also incorporate shallow excavation, increasing the long-term effectiveness and permanence of these alternatives. Once in situ treatment in Alternative 5 has been implemented, it is irreversible and thus has a high degree of long-term effectiveness. However, during implementation currently immobile NAPL may be mobilized through the heat of reaction, and would require engineering controls to mitigate potential impacts from migration. In addition, it is uncertain at this point in time, how many injections would be required to achieve remediation goals.

Alternative 2 is the least effective active alternative because it does not remove or treat COCs (other than NAPL recovery), but rather relies on institutional controls and capping to eliminate exposure pathways.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 6 offers the greatest potential reduction in TMV at the Site because it physically removes principal threat waste in accessible areas and uses proven technology; however, the waste material is transferred to another location. Alternatives 2, 3, and 5 include free-phase NAPL recovery to reduce source and mobility.

Alternatives 3, 4 and 5 would reduce TMV through in situ treatment. Each of these alternatives include the in situ solidification/stabilization of the HCAA, however Alternatives 4 and 5 would also include the in situ treatment of other principal threat waste, through solidification/stabilization and chemical treatment, respectively.

Alternatives 3, 4, and 5 incorporate testing to verify irreversibility of the remedy. The TMV reduction for Alternatives 2 and 3 is less than for Alternatives 4, 5 and 6 and the controls are potentially reversible (for example, engineering caps could be removed). The SRB treatment of dissolved-phase COCs (included in all active alternatives) may be reversible if adsorption sites are completely used up, allowing desorption to occur.

Short-Term Effectiveness

Alternatives 2 and 3 have minimal impacts with respect to the protection of workers, the community and the environment during remedial implementation, assuming adequate monitoring is conducted and mitigating actions are taken. Alternatives 4 and 5 have higher potential risks for workers, the community and the environment during implementation; engineering controls would be maintained for protection. Alternative 6 poses the highest potential risk and would require similar controls as Alternatives 4 and 5 and additional controls to mitigate potential risks to the surrounding community from increased vehicular traffic. All Alternatives would be conducted in accordance with health and safety plans.

All alternatives would potentially have environmental effects associated with stormwater runoff to some degree. The required stormwater controls would be evaluated during pre-design of the selected remedy. The potential for mobilization of NAPL during implementation of the active alternatives will be evaluated during pre-design and controls would be selected to mitigate this potential risk.

Air monitoring, appropriate personal protection equipment, and protective measures for the community would be important for all Alternatives. In addition, emission control techniques such as the use of dust suppressants and minimizing the open working area of excavations would be employed as needed to minimize adverse effects on workers and the community from volatile and dust emissions.

The time until the RAOs are achieved is estimated to be 20 to 30 years for Alternatives 2 and 3. Alternative 5 is expected to achieve RAOs within 5–10 years. Alternatives 4 and 6 would achieve RAOs most rapidly, on the order of several years.

Implementability

Implementability challenges occur at the site for each of the identified alternatives. Implementability considerations that are common to all or several alternatives are bundled under subcategories listed below. Implementability challenges that are unique to a particular alternative are identified at the end of this section.

Logistics. All alternatives would have access challenges which would have to be addressed with all property owners. For Alternatives 3, 4 and 5 the removal of the existing hotel access ramp and associated traffic diversion would be required in order to implement in situ solidification/stabilization in the portion of the HCAA on the former Celotex property. Building stability analyses and design of appropriate controls would be required prior to removal of the access ramp

Subsurface Obstructions. For Alternatives 3, 4, and 5 the removal of boulder and cobbles would have to occur in areas requiring solidification/ stabilization, which could be a significant challenge. The presence of large boulders and rip rap on the former Celotex property at NZ-5 would complicate the implementation of all active remedial technologies in this area. Installation of NAPL recovery wells (Alternatives 2, 3, and 5) would require drilling technology able to penetrate bouldery fill. Installation of a funnel and gate or PRB (Alternatives 2 and 3) would require removal of overlying bouldery fill prior to barrier placement. In situ solidification/stabilization (Alternatives 3, 4, and 5) would also require removal of subsurface boulders prior to mixing. In situ chemical treatment may require either removal of boulders or use of drilling technologies able to penetrate the fill material.

Alternatives involving in situ technologies or excavation will require working around or temporarily re-routing utilities. Temporary outages during implementation may be required.

Environmental Testing, Monitoring and Controls. Alternative 3, 4, and 5 would require bench- and pilot-scale testing prior to implementation.

Temporary controls to prevent mobilization of free-phase NAPL to OU2 would be required during implementation of in situ alternatives or deep excavation (Alternatives 4, 5, and 6) near the shoreline (at NZ-2 and NZ-5).

Water flow patterns would need to be modeled for adequate control in alternatives involving placement of barriers to groundwater flow or in situ solidification/stabilization (Alternatives 2, 3, 4, and 5).

Businesses located in 115 River Road building will need to have significant air monitoring and engineering controls as well as temporary parking accommodations during implementation of the active alternatives. These controls would be most complicated for Alternatives 5 and 6, which could result in the generation of large amounts of vapor. Alternatives 3 and 5 also include shallow excavation in areas containing free-phase NAPL, which may need to be conducted under a sprung structure.

Alternative 4 poses additional implementability considerations involving soil expansion impacts, and effective distribution of reagent to target treatment areas. Alternatives 2 and 3 involve removal of free product, which incurs additional considerations involving maintenance of system components.

Sustainability

The use of sustainable remediation concepts is relatively new to the RI/FS process and to date has been used as a "balancing criteria" for comparison between remedial alternatives that have been developed as part of the CERCLA process. The most succinct and generally agreed upon definition of sustainable remediation is "development that meets the need of the present without compromising the need of future generations, while minimizing overall burdens to society." The use of sustainable remediation criteria is used to enhance the remedy selection process and ultimately, the design and implementation of the remedy, without compromising the clean up objectives of the site. A subset of sustainable remediation is "green remediation." Green remediation focuses on techniques that can be used to enhance the sustainability of, or mitigate negative aspects of remedial alternatives that have been selected for further evaluation or that are already in operation.

There are several broad sustainability themes which can be used to compare against each alternative:

- **Beneficial reuse:** The alternative integrates easily with development plans, minimizes active / long-term operations and maintenance, and/or returns property to benefit community (park, open space)
- **Ecosystem enhancement:** The alternative uses native vegetation, enhances existing wetlands, minimizes disturbance to local habitat, wetland and water body conservation
- **Greenhouse gas emissions:** Minimal air emissions, especially greenhouse gases, minimizes vehicular traffic and truck idling, and/or minimizes dust generation during implementation
- **Energy consumption from fossil fuels:** The remedy uses zero- or low-energy demand technologies, remedy is flexible for use with onsite energy generation, equipment is energy efficient, minimizes use of long-term operations and maintenance, reduces or eliminates transportation of impacted media, use energy efficient vehicles
- **Remediation waste reduction/natural resource impacts:** The alternative results in zero waste production, use technologies that generate less waste, reuse or recycle materials

whenever possible, recycle materials after demolition, reduce groundwater extraction to minimize impacts on local water supply and surface water bodies, reclaim treated water for beneficial use such as irrigation, minimize surface water run off and/or reduce/eliminate use of off-site land filling

- **Community enhancement:** Reduce noise and lighting disturbance, reduce vehicular traffic in neighborhoods, minimize dust/odor/noise generation and/or integrate property into community development planning.

While the final end use of the property is currently unknown, it is important to consider how well the alternatives included in this feasibility study may integrate with future development options, consistent with surrounding properties. In addition, sustainability themes that can be effectively and efficiently integrated into the final remedial design and implementation will be considered.

Keeping these broad sustainability themes in mind, Alternative 4 is the most successful at achieving them. The ability to have the property ready for beneficial reuse is quickly achieved, compared to other alternatives. There is no long term mechanical O&M required and no, or very limited waste to transport. Reuse of the fill above the HCAA liner limits the need for offsite disposal and the need to transport clean fill to the site from an off-site borrow source. There would be substantially less truck traffic than any alternative requiring excavation. Noise and dust control measures can be taken to minimize impacts to the surrounding community.

Alternative 2 is moderately successful in achieving sustainability themes compared to the other alternatives. There is low energy consumption over time and minor green house gas emission during construction activities. However this alternative has both short and long term environmental impacts. There would be continued O&M required associated with product recovery, and it may not allow the site to be returned to beneficial reuse as quickly as Alternative 4. It would also be more difficult to integrate Alternative 2 into property development plans. Alternative 3 and 5 have similar impacts and are somewhat less able to achieve the sustainability themes described above. They both have the benefits of solidification/stabilization and potentially allow for faster reuse of the property than Alternative 2. However, they have machinery heavy excavations with offsite transportation and disposal, and long-term O&M requirements. Community impacts would require higher mitigation planning than Alternatives 2 and 4. Alternative 6 is the least sustainable alternative. Excavation requires heavy truck traffic, and moving waste from one area to another. In addition, it would require bringing in a substantial amount of fill to the site. It is likely that excavation would require substantial dewatering activities, that involve increased energy consumption and generates waste byproducts resulting from treatment of the groundwater. Although the site may be more quickly ready for beneficial reuse than alternatives with long term O&M commitments, and would not have the environmental impacts resulting from long term mechanical O&M, the benefits do not offset the substantial human and environmental impacts resulting from the excavation activities.

Each of the alternatives has an opportunity for green remedial design and implementation approaches to be included in the final remedy. Noise and dust reduction plans, traffic management plans, use of vegetative covers, reduction of truck idling time, the use of bio-fuels for remediation vehicles, recycling of recovered product, erosion and water

management plans, and the incorporation of native vegetation in redevelopment plans are just some items that can be incorporated as desired in the final remedial design/implementation.

Cost

A summary of the estimated costs for each of the groundwater media alternatives is presented in Table C-1 in Appendix C. The table breaks down the estimated capital, O&M, periodic, and present net worth cost.

Alternatives 5 and 6 represent the highest present worth cost alternatives at \$80 million and \$97 million, respectively. These alternatives require extensive capital equipment and labor for construction and operation. The next highest present worth cost alternative would be Alternative 3 at \$57 million. This alternative has lower capital costs but is one of the alternatives with the highest O&M cost. Alternatives 2 and 4 are the lowest cost alternatives at \$32 million and \$37 million, respectively.

Summary

This FS report presents a range of alternatives developed to address the site ARARs, RAOs, and PRGs and the principal threat and low level threat wastes identified for the site. While each of the active alternatives satisfies the two threshold criteria, they satisfy the balancing criteria to different degrees, as presented in Table 5-6. On the basis of this evaluation, Alternative 4 (in situ solidification/stabilization) best satisfies the balancing criteria, whereas Alternative 6 (excavation) is least favorable.

While each of the active alternatives satisfies the two threshold criteria, they satisfy the balancing criteria to different degrees, as presented in Table ES-2. On the basis of this evaluation, Alternative 4 (in situ solidification/stabilization) best satisfies the balancing criteria whereas Alternative 6 (excavation) is least favorable.

The following summarizes the performance of each of the alternatives with regard to the balancing criteria:

- Alternative 2 is least disruptive to the community, workers, and environment, and allows for the most rapid redevelopment of the Quanta property. However, this alternative would require the most restrictive institutional controls for future site land use due to the residual COCs that would remain onsite.
- Alternative 3 removes or solidifies/stabilizes principal threat waste and allows for relatively rapid redevelopment. However, this alternative would restrict future land use due to residual COCs that remain on site. Excavated material must be transported to and disposed of at a landfill.
- Alternative 4 solidifies/stabilizes principal threat wastes and allows for relatively rapid redevelopment without requiring contaminated soil be moved to another location. However, large fill debris that will interfere with the mixing process would need to be removed prior to treatment. Treatability studies will be conducted to (1) determine the optimal reagent mix, (2) confirm corresponding cost-effectiveness under full-scale conditions, and (3) confirm compatibility with redevelopment objectives.

- Alternative 5 treats principal threat wastes; however, this alternative takes the longest period of time to implement, significantly delaying redevelopment. In addition, excavated contaminated soil must be transported to and disposed of at a landfill. If chemical oxidation were used, it would pose potential risks of NAPL mobilization and vapor intrusion.

Alternative 6 removes the most source material from the site and allows for relatively rapid redevelopment. It is also the least restrictive of future site land uses. However, it is the most disruptive to the site and community in the short term, and significant potential risks are posed by deep excavations adjacent to buildings and roadways. In addition, large volumes of contaminated soil must be transported to and disposed of at a landfill. This FS evaluation also considered sustainability-related elements such as energy and carbon footprint reduction, waste generation reduction, timing, future land use potential, and offsite impacts in addition to the NCP criteria. In particular, due to its prime location, there is a significant benefit to the community in returning the site to productive use as soon as possible, and the alternatives are consistent with future redevelopment. In addition, the proposed groundwater component that is included in all alternatives is an energy-efficient solution that uses passive treatment, which reduces the amount of waste produced compared to other traditional approaches. Each alternative has the opportunity to include techniques during the remedial design that could enhance the overall sustainability of the alternative.

SECTION 6

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Appendix A

ARARs

Appendix A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Resource Conservation and Recovery Act	Identification and Listing of Hazardous Waste	40 CFR 261	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and 270.	ARAR for wastes or treatment residues which are hazardous as defined by RCRA and are to be disposed of off-site.
Federal Safe Drinking Water Act	National Primary Drinking Water Standards - Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs)	40 CFR 141	Establishes health-based standards for public drinking water systems. Also establishes drinking water quality goals set at levels at which no adverse health effects are anticipated, with an adequate margin of safety. The NCP specifically states that MCLs will be used as ARARs for useable aquifers rather than the more stringent MCLGs.	ARAR because the site groundwater aquifer is classified as a Class IIA Source of Drinking Water. The MCLs have been applied to the remediation of groundwater.
Federal Safe Drinking Water Act	National Secondary Drinking Water Standards-Secondary MCLs	40 CFR 143	Establishes standards for public drinking water systems for those contaminants which impact the aesthetic qualities of drinking water (secondary MCL).	To Be Considered (TBC). Secondary MCLs are based on aesthetic criteria and do not reflect public health concerns. They are considered TBC and will be attained where possible.
Quality Criteria for Water	Water Quality Criteria	40 CFR 131 Quality Criteria for Water, 1976, 1980, and 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	TBC. Water is discharged to surface water, these are used in setting effluent discharge limits.
Federal Clean Water Act; Toxic Pollutant Effluent Standards National Pollution Discharge Elimination System (NPDES)		40 CFR 129	Establishes effluent standards or prohibitions for certain toxic pollutants; i.e., aldrin/dieldrin, DDT, DDD, DDE, endrin, toxaphene, benzidine, and PCBs.	ARAR if toxic pollutants are in groundwater requiring treatment.
National Ambient Air Quality Standards (NAAQS)	Ambient Air Quality Standards	40 CFR 50	Defines air quality levels adequate to protect public health/welfare. Defines emissions limitations for sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen oxide, and lead.	Potential ARAR for remedial alternatives resulting in air emissions if these toxic pollutants are present.
Federal Resource Conservation and Recovery Act	Groundwater Protection Standards and Maximum Concentration Limits	40 CFR 264, Subpart F	Establishes standards for groundwater protection for several metals and pesticides.	ARAR. These maximum concentration limits are applicable to RCRA regulated units and are considered relevant and appropriate.

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Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements
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 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Sludge Quality Criteria	Criteria for Sludge	N.J.A.C. 7:14-4 Appendix B-1	New Jersey Water Pollution Control Act Contaminant Indicators.	Potential ARAR for remedial alternatives resulting in the generation of sludges during groundwater or soil treatment.
New Jersey Department of Environmental Protection Soil Cleanup Standards	Residential Soil Cleanup Standards in New Jersey	N.J.A.C. 7-26D	Direct contact cleanup criteria for soils at residential sites.	Potential ARAR for soil left on site in areas with potential residential use.
NJDEP Non-Residential Direct Contact Soil Cleanup Standards	Non-Residential Soil Cleanup Standards in New Jersey	N.J.A.C. 7-26D	Direct contact cleanup criteria for soils at industrial or commercial sites.	ARAR for soil left on site.
State of New Jersey Statutes and Rules	Groundwater Quality Standards	N.J.A.C. 7:9-6 Groundwater Quality Standards	Establishes standards for the protection of ambient groundwater quality. Used as the primary basis for setting numerical criteria for groundwater cleanups.	ARAR for Class IIA aquifers.
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)	Maximum Contaminant Levels	A-280 Amendments	Establishes State criteria for drinking water.	Potential ARAR if State MCLs are more stringent than Federal MCLs.
State of New Jersey Statutes and Rules	Drinking Water Standards-Maximum Contaminant Levels (MCLs)	N.J.A.C. 7:10 Safe Drinking Water Act	Establishes MCLs that are generally equal to or more stringent the SDWA MCLs.	ARAR because the site groundwater aquifer is classified as a Class IIA Source of Drinking Water.
State of New Jersey Statutes and Rules	National Secondary Drinking Water Standards-Secondary MCLs	N.J.A.C. 7:10-7 Safe Drinking Water Act	Establishes standards for public drinking water systems for those contaminants which impact the aesthetic qualities of drinking water.	TBC. Secondary MCLs are based on aesthetic criteria and do not reflect public health concerns. They are considered TBCs in that they will be attained where possible.

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Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
New Jersey Pollutant Discharge Elimination System (NJPDES)	Surface Water Discharge Criteria	N.J.A.C. 7:14a	Establishes discharge standards when written into permits.	Potential ARAR if treated water is discharged to surface water.
Surface Water Criteria	New Jersey Criteria for Surface Water Quality	N.J.A.C. 7:9-4	Criteria for surface water classes	Potential ARAR if treated water is discharged to surface waters.
Prohibition of Air Pollution and Ambient Air Quality Standards	Air Quality Standards	N.J.A.C. 7:27-5 and N.J.A.C. 7:27-13	Prohibits air pollution and establishes ambient air quality standards	Potential ARAR for remedial alternatives which include technologies that result in air emissions.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Discharge of Groundwater or Wastewater				
Federal Clean Water Act	National Pollution Discharge Elimination System (NPDES)	40 CFR 122 and 125	Issues permits for discharge into navigable waters. Establishes criteria and standards for imposing treatment requirements on permits.	ARAR, although state ARAR takes precedence for discharge permit. Disposal of groundwater to the surface water. NPDES permit may not be required since New Jersey has an approved SPDES permit program (NJDPES).
Federal Clean Water Act	General Pretreatment Regulations for Existing and New Sources of Pollution	40 CFR 403	Prohibits discharge of pollutants to a POTW which cause or may cause pass-through or interference with operations of the POTW.	ARAR. Discharge of pollutants including those that could cause fire or explosion or result in toxic vapors or fumes to POTW.
Federal Clean Water Act	Effluent Guidelines and Standards for the Point Source Category	40 CFR 414	Requires specific effluent characteristics for discharge under NPDES permits.	ARAR, although state ARAR takes precedence for discharge permit. Disposal of groundwater to the surface water. NPDES permit may not be required since New Jersey has an approved SPDES permit program (NJDPES).
Federal Safe Drinking Water Act	Underground Injection Control Program	40 CFR 144	Establishes performance standards, well requirements, and permitting requirements for groundwater re-injection wells.	Potential ARAR if remedial alternative includes discharge of treated groundwater to potable water supply aquifer. May also apply to the injection of surfactants or oxidants into the aquifer.
Federal Clean Water Act	Ambient Water Quality Criteria	40 CFR 131.36	Establishes criteria for surface water quality based on toxicity to aquatic organisms and human health.	Potential ARAR if remedial alternative includes groundwater discharge to surface water. Federally-approved New Jersey groundwater and surface water standards take precedence over the Federal criteria.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Clean Water Act	Water Quality Criteria Summary		Includes non-promulgated guidance values for surface water based on toxicity to aquatic organisms and human health. Issued by the EPA office of Science and Technology, Health and Ecological Criteria Division.	Potential ARAR if remedial alternative includes groundwater discharge to surface water. Supplements above-referenced Ambient Water Criteria.
Water Pollution Control Act	Protection of water	33 U.S.C. 1251	Protects and maintains the chemical, physical, and biological integrity of the nation's water.	Potential ARAR for remedial actions which may affect water quality.
Water Treatment and Disposal				
Effluent Limitations	Discharge requirements	33 U.S.C. 1251 Section 301	Technology-based discharge limitations for point sources of conventional, nonconventional, and toxic pollutants.	Potential ARAR for remedial actions which include discharge of wastewater.
Water Quality Related Effluent Limitations	Discharge requirements	33 U.S.C. 1251 Section 302	Protection of intended uses of receiving waters (e.g., public water supply, recreations uses).	Potential ARAR for remedial actions which include discharge of wastewater.
Toxic and Pretreatment Effluent Standards	Pretreatment standards for discharge into POTWs.	33 U.S.C. 1251 Section 307	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge into POTWs.	Potential ARAR for remedial actions which include discharge of wastewater.
National Pollutant Discharge Elimination System (NPDES)	Permitting for discharge into navigable waters.	33 U.S.C. 1251	Issues permits for discharge into navigable waters.	Potential ARAR for remedial actions involving discharge to surface water.
Disposal of Dredged and Fill Material	Requires permitting of discharges of dredged and fill material to navigable waters.	33 U.S.C. 1251 Section 404	Requires permitting of discharges of dredged and fill material to navigable waters.	Potential ARAR for remedial alternatives which require discharge of dredged and fill material to navigable waters.
State of New Jersey Statutes and Rules	The New Jersey Pollutant Discharge Elimination System	N.J.A.C. 7:14A	Establishes standards for discharge of pollutants to surface and groundwaters.	ARAR. New Jersey has a state approved program. Disposal of treated groundwater to surface water.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
State of New Jersey Statutes and Rules	Groundwater Quality Standards	N.J.A.C. 7:9-6 Groundwater Quality Standards	Establishes standards for the protection of ambient groundwater quality. Used as the primary basis for setting numerical criteria for groundwater cleanups and discharges to groundwater.	ARAR. Disposal of treated groundwater by reinjection.
State of New Jersey Statutes and Rules	Surface Water Quality Standards	N.J.A.C. 7:9B Surface Water Quality Standards	Establishes standards for the protection and enhancement of surface water resources.	ARAR. Disposal of treated groundwater by discharge to surface water.
Wastewater Discharge Requirements	Wastewater discharge requirements	N.J.A.C. 7:9-5.1	Minimum treatment requirements and effluent standards for discharge to surface water.	Potential ARAR if waters generated by treatment technology are discharged to surface water.
Worker and Community Right to Know Act	Protects workers and community	P.L. 1983c.315 P.L. 1985c.543 Executive Order #161	Notification of presence of hazardous substances to State Emergency Planning Commissions and to local Emergency Planning Committees.	ARAR. Applies to all on-site treatment alternatives.
Safe Drinking Water	Protects public water supply wells	N.J.S.A. 58:12A	Regulates periodic testing of Public Community Water Systems.	ARAR. Periodic water supply monitoring may be part of the remediation alternatives.
Interim Safe Drinking Water Testing Schedule	Protects public water supply wells	N.J.A.C. 7:10-14.1 et.seq.	Requires periodic testing, analysis, and reporting for Public Community Water Systems.	ARAR. Periodic water supply monitoring may be part of the remediation alternatives.
New Jersey Safe Drinking Water Act	Protects public water supply wells	N.J.A.C. 7:10	Sets standards for drinking water including MCLs, disinfecting requirements, secondary drinking water regulations, and monitoring requirements.	Potential ARAR if criteria are more stringent than the Federal MCLs.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Disposal of Hazardous Waste				
RCRA Criteria for Classification of Solid Waste Disposal Facilities and Practices	Classification of Disposal Facilities	40 CFR 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby constitute prohibited open dumps.	Potential ARAR for remedial alternatives which include disposal of non-hazardous waste on-site. The current Subtitle D program is principally aimed at municipal and industrial solid waste.
RCRA Hazardous Waste Management Systems, General	General Waste Management Practices	40 CFR 260	Establishes procedures and criteria for modification or revocation of any provision in 40 CFR Part 260-265.	Potential ARAR. Establishes general requirements for hazardous waste management.
Federal Resource Conservation and Recovery Act	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies solid wastes which are subject to regulation as hazardous wastes.	ARAR. Generation of a hazardous waste possibly including spent carbon or contaminated soil. Hazardous waste must be handled and disposed of in accordance with RCRA. Chemical testing and characterization of waste required.
Federal Resource Conservation and Recovery Act	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes requirements (e.g., EPA ID numbers and manifests) for generators of hazardous waste.	ARAR. Waste that is characterized as hazardous.
Federal Resource Conservation and Recovery Act	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards which apply to persons transporting manifested hazardous waste within the United States.	ARAR. Transport of waste that is characterized as hazardous.
Federal Resource Conservation and Recovery Act	Standards Applicable to Owners and Operators of Treatment, Storage and Disposal Facilities	40 CFR 264	Establishes the minimum national standards which define acceptable management of hazardous waste.	ARAR. Generation and storage of hazardous waste.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Resource Conservation and Recovery Act	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 265	Establishes minimum national standards that define the periods of interim status and until certification of final closure or if the facility is subject to post-closure requirements, until post-closure responsibilities are fulfilled.	Potential ARAR since remedies should be consistent with the more stringent 40 CFR 264 standards, as these represent the ultimate RCRA compliance standards and are consistent with CERCLA's goal of long-term protection of public health and welfare and the environment.
Federal Resource Conservation and Recovery Act	Interim Standards for Owners and Operators	40 CFR 267	Establishes minimum national standards that define acceptable management of hazardous waste for new land disposal facilities.	Potential ARAR. CERCLA actions should be consistent with requirements of 40 CFR 264.
Federal Resource Conservation and Recovery Act	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes which are restricted from land disposal. All listed and characteristic hazardous waste or soil or debris contaminated by a RCRA hazardous waste and removed from a CERCLA site may not be land disposed until treated as required by LDRs.	ARAR. Waste to be disposed as a RCRA waste.
Federal Resource Conservation and Recovery Act	Hazardous Waste Permit Program	40 CFR 270	Establishes provisions covering basic EPA permitting requirements.	Potential ARAR. A permit is not required for on-site CERCLA response actions. Substantive requirements are added in 40 CFR 264.
State of New Jersey Statutes and Rules	Hazardous Waste	N.J.A.C. 7:26C Hazardous Waste	Establishes rules for the operation of hazardous waste facilities in the state of New Jersey	Potential ARAR depending on hazardous waste disposal location.
Federal Resource Conservation and Recovery Act	RCRA	40 CFR 265	Establishes organic air emission standards for tanks, surface impoundments, and containers.	Potential ARAR for hazardous waste treatment, storage, and disposal facilities (TSDFs) that receive new or re-issued permits or Class 3 modifications after 5 January 1995.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Hazardous Material Transportation Act	Hazardous Materials Transportation Regulations	49 CFR 107, 171-177	Regulates transportation of hazardous materials.	Potential ARAR since response action may involve transportation of hazardous materials.
General Remediation				
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and Superfund Amendments and Reauthorization Act of 1986 (SARA)	National Contingency Plan	40 CFR 300, Subpart E	Outlines procedures for remedial actions and for planning and implementing off-site removal actions.	ARAR.
State of New Jersey Statutes and Rules	Technical Requirements for Site Remediation	N.J.A.C. 7:26E	Established minimum regulatory requirements for investigation and remediation of contaminated sites in New Jersey.	ARAR.
Federal Occupational Safety and Health Act	Worker Protection	29 CFR 1904	Requirements for recording and reporting occupation injuries and illnesses	ARAR. Under 40 CFR 300.38, requirements of OSHA apply to all activities which fall under jurisdiction of the National Contingency Plan.
Emergency Response Notice of Release of Hazardous Substance to Atmosphere	Notification of Air Releases	NJSA 7:26, 26:2C-19	Control exposure to air pollution by immediate notification to the department hotline of any air release incident.	Potential ARAR for any remedial alternative having the potential to result in an air release.
Water Pollution Control	Notification of Spills	NJAC 7:21(E)	Immediate notification of any spill of hazardous substances.	Potential ARAR for remedial alternatives having potential for a spill of a hazardous substance.
Noise Control Act	Restrictions of Noise	NJSA 13:1G-1 et.seq.	Prohibits and restricts noise which unnecessarily degrades the quality of life.	Potential ARAR for all remedial action.

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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Disposition of Material Generated During Site Investigations (NJDEP)	Investigation derived waste management	NJDEP's Guidance Document	Provides guidance on the disposition of IDW.	Potential ARAR. To be considered during investigation.
Noise Pollution	Restrictions of Noise	NJAC 7:29-1	Sets maximum limits of sound from any industrial, commercial, public service or community service facility.	Potential ARAR for all remedial actions.
Federal Occupational Safety and Health Act	Worker Protection	29 CFR 1904	Worker Protection	ARAR. Under 40 CFR 300.38, requirements of OSHA apply to all activities which fall under jurisdiction of the National Contingency Plan.
General Requirements for Permitting Wells	Well Permitting	NJAC 7:9-7	Regulates permit procedures, general requirements for drilling and installation of wells, licensing of well driller and pump installer, construction specification, and well casing.	Potential ARAR when installing new wells or if existing wells should require modification.
Sealing of Abandoned Wells	Well Abandonment Procedures	NJAC 7:9-9	General requirements for sealing of all wells (e.g., single cased, multiple cased, hand dug, test wells, boreholes and monitoring wells, abandoned wells).	Potential ARAR if any existing wells need to be abandoned and sealed.
Well Drillers and Pump Installers Act	Drilling Contractor Requirements	NJSA 58:4A-5 et.seq.	Well drillers licensing, supervision, inspection and sampling.	Potential ARAR when additional wells are installed.
Requirement for Groundwater Monitoring	Groundwater Monitoring	N.J.A.C. 7:26-9	Groundwater monitoring system requirements.	Potential ARAR for any remedial alternative requiring groundwater monitoring.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Off-Gas Management				
Federal Clean Air Act	National Primary and Secondary Ambient Air Quality Standards	40 CFR 50	Establishes emission limits for six pollutants (SO ₂ , PM ₁₀ , CO, O ₃ , NO ₂ , and Pb).	Emission of air pollutants may be of concern for some remedial technologies.
Permitting Requirements	Permitting Conditions for air pollution control	N.J.A.C. 7:27-8	Establishes permit conditions for air pollution control apparatus.	ARAR if remedial action includes a technology that would result in air emissions.
Air Pollution Control	Permitting Conditions for air pollution control	N.J.A.C. 7:27-11 and 17	Controls and prohibits air pollution, particle emissions, and toxic VOC emissions.	Potential ARAR if remedial action includes a technology that would result in air emissions.
Operating Standards for Hazardous Waste Incinerators	Incineration Requirements	N.J.A.C. 7:26-10	Specifies maximum air contaminant emissions rates, testing requirements; and minimum design standards.	Potential ARAR if remedial alternative includes incineration.
Interim Standards for Hazardous Waste Incinerators.	Incineration Requirements	N.J.A.C. 7:26-11	Specifies maximum air containment emission rates, testing requirement, and minimum design standards during interim status.	Potential ARAR if remedial alternative includes incineration.
Incinerator Permit Regulations	Incinerator Permitting	N.J.A.C. 7:26-12	Delineates the information needs to be submitted in Part A and B of the permit application.	Potential ARAR if remedial alternative includes incineration.
Federal Clean Air Act	Standards of Performance for New Stationary Sources	40 CFR 60	Provides emissions requirements for new stationary sources.	ARAR.
Federal Clean Air Act	National Emission Standards for Hazardous Air Pollutants	40 CFR 61	Provides emission standards for 8 contaminants including benzene and vinyl chloride. Identifies 25 additional contaminants, as having serious health effects but does not provide emission standards for these contaminants.	ARAR.
State of New Jersey Statutes and Rules	Standards for Hazardous Air Pollutants	N.J.A.C. 7:27 Air Pollution Control	Rule that governs the emitting of, and such activities that result in, the introduction of contaminants into the ambient atmosphere.	ARAR.

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Potential Location-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site, OU1
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Executive Order Floodplain Management	Floodplain Management	Exec. Order No. 11988 40 CFR 261.10(b) and Appendix A	Requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the maximum extent possible, the adverse impacts associated with direct and indirect development of a floodplain.	Potential ARAR if remedial activities take place in or near a 100-year or 500-year floodplain.
Federal Flood Plains Regulatory Requirements	Regulatory Requirements	(RCRA Location Standards (40 CFR 264.18)	This regulation outlines the requirements for constructing a RCRA facility on a 100-year flood plain.	Potential ARAR if remedial alternatives include construction in or near a 100-year floodplain.
Clean Water Act	Prohibits discharge of dredged or fill material into wetlands	33 U.S.C. 1251 Section 404, 40 CFR 230, 231	Prohibits discharge of dredged or fill material into wetlands without a permit. Preserves and enhances wetlands.	Potential ARAR for remedial alternatives which involve disturbance to wetlands.
Policy Floodplains/Wetlands Assessment	Floodplain assessment	EPA 1985 Statement	Provides federal policy for the assessment of floodplains and wetlands	Potential ARAR for remedial alternatives that affect wetlands and floodplains.
National Historic Preservation Act	Protects historic places	16 U.S.C. 470	Requires federal agencies to take into account the effect of any federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or is eligible for inclusion in the National Register of Historic Places.	ARAR since source areas are included or eligible for inclusion in the National Register of Historic Places.
U.S. Army Corps of Engineers Nationwide Permit Program	Army Corp. of Engineers Permit Program	33 CFR 330	Prohibits activity that adversely affects a wetland if a practical alternative that has less effect is available.	Potential ARAR for remedial alternatives which have the potential to affect wetlands.
Rivers and Harbors Act of 1899	Army Corp. of Engineers Permit Program	33 CFR 320-330	Establishes a COE permit program for dams, dikes, dredging, and other construction in navigable waters of the U.S.	Potential ARAR if remedial actions occur on Federal Property.

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Potential Location-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site, OU1
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Executive Order Protecting Wetlands	Protection of Wetlands	Executive Order No. 11990	Requires Federal agencies to minimize the destruction, loss, or degradation of all wetlands affected by Federal activities.	Potential ARAR for remedial alternatives which have the potential to affect wetlands.
Fish and Wildlife Coordination Act	Requires approval for modification of water body	16 U.S.C. 661 40 CFR 2 6.302(g)	Requires consultation with the U.S. Fish and Wildlife Services when a Federal department or agency proposes or authorizes any modification of any stream or other water body, and adequate provision for protection of fish and wildlife resources.	Potential ARAR since any disturbance and restoration or replacement of wetlands must be coordinated with the Fish and Wildlife Service.
National Ambient Air Quality Standards (NAAQS)	Air Quality Standards	40 CFR 50	Establishes non-attainment zones with respect to health-based criteria.	Potential ARAR for remedial activities which emit restricted contaminants into the atmosphere.
Federal Endangered and Non-Game Species Act	Protection of threatened and endangered species	N.J.S.A. 23:2A- 1	Standards for the protection of threatened and endangered species.	Not an ARAR because no listed species identified at the site.
Flood Hazard Area Regulations	Protection of floodplains	N.J.A.C. 7:13	Protects floodplains through permitting requirements for construction and development activities	Potential ARAR if remedial activities are located in or near a 100- or 500-year floodplain.
Flood Hazard Area Control Act	Delineates flood hazard areas	N.J.S.A. 58: 16A-50	Delineates flood hazard areas and regulates use.	Potential ARAR if remedial activities are in or near a 100- or 500-year floodplain.
Wetland Act of 1970	Establishes wetland regulated activities	N.J.S.A. 13:9A- 1 et.seq.	Establishes listing and permitting requirements for regulated activities	Potential ARAR. Establishes listing and permitting requirements for regulated activities

Appendix A
Potential Location-Specific Applicable or Relevant and Appropriate Requirements
 Quanta Resources Superfund Site, OU1
 Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Freshwater Wetlands Protection Act	Establishes freshwater wetlands regulated activities	N.J.S.A. 13:9B	Establishes listings and permitting requirements for regulated activities in state freshwater wetlands	Potential ARAR. Establishes listings and permitting requirements for regulated activities in state freshwater wetlands
Open Lands Management	Considers recreational projects during remediation	N.J.A.C. 7:2-12.1 et seq.	Considers impact of remedial actions on recreational projects funded by Open Lands Management Grants.	Potential ARAR for remedial actions on recreational projects funded by Open Lands Management Grants.
Natural Areas System	Protects natural area sites	N.J.A.C. 7:2-11	Protects natural area sites listed under the Natural Areas Register.	Potential ARAR if remedial actions occur on natural area sites listed under the Natural Areas Register.
State Trails System	Protects state trails	N.J.S.A. 13:8-30 et. seq.	Requires that use of trail does not interfere with nature; maintains natural and scenic qualities.	Potential ARAR. Requires that use of trail does not interfere with nature; maintains natural and scenic qualities.
New Jersey Wild and Scenic Rivers System	Protects Scenic River systems	N.J.S.A. 13:8-45 et. seq.	Governs component river area, flood hazard area, or part of state park, wildlife refuge or similar area.	Potential ARAR. Governs component river area, flood hazard area, or part of state park, wildlife refuge or similar area.
New Jersey Threatened Plant Species	Lists threatened plant species	New Jersey's Threatened Plant Species	Lists threatened plant species	Potential ARAR if remedial actions impact threatened plant species.
Endangered Plant/Animal Species Habitats	Lists threatened habitats where endangered species occur	New Jersey's Endangered Species Act	Lists threatened habitats where endangered species occur	Potential ARAR. Lists threatened habitats where endangered species occur.

Appendix B
ISCO Bench-Scale Treatability Test

In-Situ Chemical Oxidation Treatability Study Results Quanta Resources Superfund Site, Operable Unit 1

PREPARED BY: CH2M HILL

DATE: September 24, 2008

Introduction

As discussed in the November 21, 2006 response to EPA comments on the Draft Candidate Technologies Memorandum for the Quanta Resources Superfund Site ("Site"), EPA's comment letter dated July 28, 2006 requested the submission of a treatability testing work plan for chemical oxidation and other technologies. A work plan to conduct a bench scale treatability test of in-situ chemical oxidation (ISCO) was submitted to EPA on February 6, 2007. Work initiated with the collection of soil and groundwater samples on March 27, 2007. EPA comments on the work plan were received on April 4, 2007 and the analytical suite for the test was modified in response to the comments, including the addition of arsenic speciation analyses. A table providing responses to each of EPA's comments on the work plan is attached to this memorandum.

The bench-scale treatability test was conducted by Geo-Cleanse® International, Inc. (Kenilworth, NJ), and laboratory analysis was conducted by Accutest Laboratories (Dayton, NJ) and Applied Speciation and Consulting, LLC (Tukwila, WA).

The ISCO treatability test was designed to:

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both.
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site.
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO.
- Estimate total oxidant demand of the media.
- Determine the relative fractions of contaminants that are oxidized, volatilized, and leached during the ISCO process.
- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard may be created.

The three general soil types encountered at the site were included in the testing to gain an understanding of how each ISCO reagent would work on the various soils present at the site. The three soil types are:

- Silty sand with visible coal tar (SS-1)

- Silty sand with residual coal tar (SS-2)
- Peat with residual coal tar (P-1)

Soil and groundwater samples were collected on March 27, 2007 in accordance with the Draft In-Situ Chemical Oxidation Treatability Study Work Plan submitted on February 6, 2007. A back hoe was used to excavate the proposed soil sample locations and collect sample material. SS-1 and SS-2 were moved from the locations indicated in the work plan because a concrete pad was encountered at approximately 2 ft bgs. Groundwater was collected with a whale pump from each well selected. The sample locations are described as follows:

- SS-1 - The soil was collected approximately 10 ft northwest of the MW-103 cluster at a depth of 6 - 8 ft bgs. Groundwater was collected from MW-102 which is screened from 4 - 9 ft bgs with the pump set at 6 ft bgs.
- SS-2 - The soil was collected approximately 10 ft northwest of the MW-103 cluster (from the same excavation as SS-1) at a depth of 3 ft bgs. Groundwater was collected from MW-102B which is screened from 14 - 24 ft bgs with the pump set at 14 ft bgs.
- P-1 - The soil was collected approximately 80 ft southwest of the MW-112 cluster at a depth of 9 ft bgs. Groundwater was collected from MW-112B which is screened from 2 - 12 ft bgs with the pump set at 7 ft bgs.

Treatability testing components included evaluation of baseline soil samples, soil buffering and reactivity tests, peroxide reactivity tests, slurry oxidation tests, soil column tests, and autoclave tests. A report of the treatability testing results prepared by Geo-Cleanse® is attached to this memorandum, and includes descriptions of the tests, and presentation and discussion of the results. Preliminary observations based directly on results of the bench-scale test are included in this memorandum.

The total concentrations of VOCs and SVOCs (including tentatively identified compounds) detected in the baseline samples and shown in Tables 4-1, 4-2 and 4-3 of the report are as follows:

Sample	Total VOCs and SVOCs in Groundwater	Total VOCs and SVOCs in Soil
	(micrograms per liter)	(micrograms per kilogram)
SS-1	67,370	71,574,900
SS-2	33,003	33,900,030
P-1	31,873	323,138

Oxidant-to-contaminant ratios of 10:1, 20:1 and 40:1 of Fenton's reagent and base-catalyzed sodium persulfate were evaluated during the treatability test. Permanganate is not capable of oxidizing aromatic ring structures, including BTEX and PAHs (reactions with PAHs predominantly affect alkyl groups and do not involve ring cleavage) and was therefore not included in the treatability test.

Bench-Scale Test Results

The results of the bench-scale test are presented in the attached results report prepared by Geo-Cleanse®. The bench-scale results cannot be used to quantitatively predict pilot or full-scale application results; however qualitative predictions can be made regarding potential remedy effectiveness. A summary of key conclusions of the bench test is provided below.

Based on visual observations during the slurry tests, free-phase NAPL was either destroyed or was transformed to a non-mobile condition by both oxidants at the minimum tested dosage of 10:1.

The slurry tests, soil column tests, and autoclave tests all indicated that Fenton's reagent was a more efficient oxidant than persulfate for the soils used in the test. Fenton's reagent yielded 59-99% oxidation of total contaminant mass depending upon oxidant dosage, whereas persulfate yielded 3-93% oxidation. Persulfate was relatively ineffective for the P-1 sample, achieving 3-35% contaminant mass oxidation.

In the autoclave test, Fenton's reagent was a more efficient oxidant than persulfate. Results for both oxidants indicate that oxidation, rather than leaching or volatilization, were the predominant mechanisms for loss of VOCs and SVOCs from the treated soils. Volatilization and leaching from the soils were negligible relative to oxidation. Although oxidation was the primary mechanism for loss of VOCs and SVOCs, even small amounts of increased volatilization may pose risks associated with vapor intrusion, which would need to be evaluated and controlled during a pilot-scale or full-scale implementation.

ISCO affected the aqueous concentrations of several inorganic constituents, including arsenic. Sulfate and iron concentrations increased, since these constituents are components of the oxidation reagents. Concentrations of several metals increased, including arsenic, chromium, cadmium, selenium, and lead. These metals may have been either mobilized from the soil or present in the catalyst used during the test. Total arsenic concentrations increased in tests for both SS-1 and SS-2 samples, but almost all of the arsenic was oxidized from As(III) to As(V). The arsenic compounds which contain As(V) are negatively charged and therefore have a greater affinity for adsorption compared to neutrally charged compounds containing As(III). In the peat sample, total arsenic concentrations decreased in the treated slurries, but remained well above the NJ Groundwater Quality Standard for arsenic of 3 micrograms per liter ($\mu\text{g/L}$).

Sample	Initial Arsenic		Final Arsenic – Fenton's Slurry Test						Final Arsenic – Persulfate Slurry Test					
	Soil	Ground	Soil			Groundwater			Soil			Groundwater		
	(mg/kg)	-water	(mg/kg)			(µg/L)			(mg/kg)			(µg/L)		
		(µg/L)												
	Oxidant-to-Contaminant Ratio		10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
SS-1	20.6	20.6	16.1	14.9	16.0	459	558	590	7.5	4.9	ND	499	683	385
SS-2	9.9	342	6.1	9.2	12.6	583	928	262	7.7	4.2	8.9	480	767	834
P-1	ND	13,500	64.3	59.9	62.6	132	183	2,690	41.1	43.2	37.1	1,370	4,080	2,550

Sample	Initial Arsenic		Final Arsenic – Fenton's Slurry Test						Final Arsenic – Persulfate Slurry Test					
	Soil	Ground	Soil			Groundwater			Soil			Groundwater		
	(mg/kg)	-water (µg/L)	(mg/kg)			(µg/L)			(mg/kg)			(µg/L)		
Oxidant-to-Contaminant Ratio			10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
SS-1	20.6	20.6	16.1	14.9	16.0	459	558	590	7.5	4.9	ND	499	683	385
SS-2	9.9	342	6.1	9.2	12.6	583	928	262	7.7	4.2	8.9	480	767	834
P-1	ND	13,500	64.3	59.9	62.6	132	183	2,690	41.1	43.2	37.1	1,370	4,080	2,550

Evaluation of ISCO Effectiveness

Based on the results of the tests as reported by Geo-Cleanse®, ISCO appears to be applicable in general for treatment of VOCs and SVOCs in NAPL-impacted soils from the Site under laboratory conditions. Fenton's appears to be more effective on tested soils while Fenton's and persulfate are about equally effective on tested groundwater. Sodium persulfate applicability appears more limited in peat-rich soil areas at the Site relative to Fenton's reagent at the application concentrations used. Therefore, based on overall mass, the reduction appears better for tests using Fenton's – at the application concentrations used. However, only first order kinetics were taken into account, which may underestimate the overall effectiveness of persulfate due to its anticipated greater longevity in the subsurface compared to Fenton's reagent.

Evaluation of ISCO Implementability

The bench test results have uncertainties which must be considered when evaluating full-scale implementability of ISCO at the Site. Mixing of the contaminants and oxidant will likely not occur as ideally in the subsurface environment as in the bench test. Similarly, oxidant and catalyst will not likely completely mix during full scale implementation. Heat generated during the oxidation reactions and transferred throughout the subsurface will impact NAPL mobility in ways that cannot be evaluated in a bench test. The ability of a relatively small amount of soil and groundwater used in the bench test to accurately represent the subsurface environment in the entire Site is also a considerable uncertainty. However, based on Geo-Cleanse's past experience, the prediction of oxidant demand from the bench test is usually relatively close to the oxidant demand determined during pilot testing for site with contaminants similar to the Site.

The mass of oxidants used in the tests (necessary to treat the very high oxidant demand posed by the large mass of VOCs and SVOCs) may be significantly greater than the amount of oxidant that could be effectively delivered to the subsurface in a field application. Persulfate's limit is from 10 to 15% of soil weight (assuming the total soil porosity is between 25% to 30% and a maximum weight percent of persulfate in solution of 30%), or up to 0.15 of 0.5 kg, or 75 grams for the sample volume used in the SS-1 and SS-2 slurries. The sodium persulfate used in the slurry tests for these two samples ranged from 170.0 grams (10:1 ratio, SS-2 sample) to 1,435.5 grams (40:1 ratio, SS-1 sample). In order to apply this

amount of oxidant in the field would require 3 to 19 successive applications (spaced from 4 months to 1 year apart). Similar restrictions apply to Fenton's since it would not be safe to inject at more than about 15% solution. The high oxidant demand required to appreciably reduce VOC and SVOC concentrations (albeit not to levels low enough to approach preliminary remediation goals) apply to any chemical oxidation technology for the site, not only Fenton's and persulfate.

Although oxidation was the primary mechanism for loss of VOCs and SVOCs, even small amounts of increased volatilization may pose risks associated with vapor intrusion, which would need to be evaluated and controlled during field implementation. The increases in arsenic concentrations observed in the silty sand samples as a result of ISCO would also need to be monitored and managed during field implementation.

Health and safety and transportation issues associated with hydrogen peroxide as a liquid are more serious than those of sodium persulfate as a dry powder. Fenton's application likely requires denser spaced injection locations to distribute the oxidant for maximum contact as fast as possible, in contrast to persulfate. The heat and gas generation associated with Fenton's can pose issues - as observed in the bench-scale tests, gas evolution hinders effective flow, and can impede effective delivery of the oxidant as a fluid during injection. The heat and gas can enhance daylighting, thus slower injection rates can be achieved than with persulfate. The high oxidant demand at the site required to achieve a significant reduction in COC concentrations pose significant technical challenges as discussed above and may render this technology cost-prohibitive in a full-scale application at the site. Even if full scale application was implemented, the bench test indicates that COCs will remain in the soil at concentrations exceeding PRGs.

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Baseline Data		SS-1 Slurry Test Data											
			Persulfate 10:1 (SS1-P-10)		Persulfate 20:1 (SS1-P-20)		Persulfate 40:1 (SS1-P-40)		Fenton 10:1 (SS1-F-10)		Fenton 20:1 (SS1-F-20)		Fenton 40:1 (SS1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Volatiles (ug/L or ug/kg)														
1,1,1-Trichloroethane	ND (<14)	ND (<980)	ND (<1.4)	ND (<2,600)	ND (<1.4)	ND (<2,400)	ND (<1.4)	ND (<58)	ND (<1.5)	ND (<43)	ND (<1.5)	ND (<4.6)	ND (<1.5)	ND (<1.0)
1,1,2,2-Tetrachloroethane	ND (<14)	ND (<950)	ND (<1.4)	ND (<2,500)	ND (<1.4)	ND (<2,300)	ND (<1.4)	ND (<57)	ND (<4.0)	ND (<33)	ND (<4.0)	ND (<3.6)	ND (<4.0)	ND (<0.79)
1,1,2-Trichloroethane	ND (<16)	ND (<890)	ND (<1.6)	ND (<2,400)	ND (<1.6)	ND (<2,100)	ND (<1.6)	ND (<53)	ND (<2.5)	ND (<33)	ND (<2.5)	ND (<3.6)	ND (<2.5)	ND (<0.79)
1,1-Dichloroethane	ND (<12)	ND (<790)	ND (<1.2)	ND (<2,100)	ND (<1.2)	ND (<1,900)	ND (<1.2)	ND (<47)	ND (<1.0)	ND (<78)	ND (<1.0)	ND (<8.4)	ND (<1.0)	ND (<1.9)
1,1-Dichloroethene	ND (<16)	ND (<1,100)	ND (<1.6)	ND (<3,000)	ND (<1.6)	ND (<2,700)	ND (<1.6)	ND (<68)	ND (<1.4)	ND (<52)	ND (<1.4)	ND (<5.6)	ND (<1.4)	ND (<1.3)
1,2,4-Trichlorobenzene	ND (<8)	ND (<580)	ND (<0.8)	ND (<1,500)	ND (<0.8)	ND (<1,400)	ND (<0.8)	ND (<35)	ND (<2.0)	ND (<40)	ND (<2.0)	ND (<4.3)	ND (<2.0)	ND (<0.95)
1,2-Dibromo-3-chloropropane	ND (<55)	ND (<3,600)	ND (<5.5)	ND (<9,400)	ND (<5.5)	ND (<8,600)	ND (<5.5)	ND (<210)	ND (<4.0)	ND (<110)	ND (<4.0)	ND (<11)	ND (<4.0)	ND (<2.5)
1,2-Dibromoethane	ND (<26)	ND (<930)	ND (<2.6)	ND (<2,500)	ND (<2.6)	ND (<2,300)	ND (<2.6)	ND (<56)	ND (<2.2)	ND (<33)	ND (<2.2)	ND (<3.6)	ND (<2.2)	ND (<0.79)
1,2-Dichlorobenzene	ND (<10)	ND (<750)	ND (<1.0)	ND (<2,000)	ND (<1.0)	ND (<1,800)	ND (<1)	ND (<45)	ND (<0.98)	ND (<31)	ND (<0.98)	ND (<3.4)	ND (<0.98)	ND (<0.75)
1,2-Dichloroethane	ND (<15)	ND (<900)	ND (<1.5)	ND (<2,400)	ND (<1.5)	ND (<2,200)	ND (<1.5)	ND (<54)	ND (<1.4)	ND (<27)	ND (<1.4)	ND (<2.9)	ND (<1.4)	ND (<0.64)
1,2-Dichloropropane	ND (<10)	ND (<920)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,200)	ND (<1)	ND (<55)	ND (<1.2)	ND (<47)	ND (<1.2)	ND (<5.0)	ND (<1.2)	ND (<1.1)
1,3-Dichlorobenzene	ND (<16)	ND (<810)	ND (<1.6)	ND (<2,100)	ND (<1.6)	ND (<1,900)	ND (<1.6)	ND (<48)	ND (<1.0)	ND (<42)	ND (<1.0)	ND (<4.5)	ND (<1.0)	ND (<0.99)
1,4-Dichlorobenzene	ND (<12)	ND (<760)	ND (<1.2)	ND (<2,000)	ND (<1.2)	ND (<1,800)	ND (<1.2)	ND (<45)	ND (<0.84)	ND (<34)	ND (<0.84)	ND (<3.6)	ND (<0.84)	ND (<0.81)
2-Butanone (MEK)	ND (<130)	ND (<4,500)	ND (<13)	ND (<12,000)	ND (<13)	ND (<11,000)	ND (<13)	ND (<270)	ND (<14)	ND (<320)	ND (<14)	ND (<34)	ND (<14)	30.6
2-Hexanone	ND (<63)	ND (<2,200)	ND (<6.3)	ND (<6,000)	ND (<6.3)	ND (<5,400)	ND (<6.3)	ND (<130)	ND (<4.7)	ND (<200)	ND (<4.7)	ND (<21)	ND (<4.7)	ND (<4.7)
4-Methyl-2-pentanone(MIBK)	ND (<53)	ND (<3,300)	ND (<5.3)	ND (<8,700)	ND (<5.3)	ND (<7,900)	ND (<5.3)	ND (<200)	ND (<6.9)	ND (<220)	ND (<6.9)	ND (<24)	ND (<6.9)	ND (<5.3)
Acetone	ND (<120)	ND (<4,700)	ND (<12)	ND (<13,000)	ND (<12)	ND (<11,000)	ND (<12)	ND (<280)	782	1,060 J	371	ND (<50)	133	137
Benzene	5,530	20,800	91.7	14,200	18.9	7,280	3.1 J	1,250	ND (<0.97)	1,020	4.9 J	148	1.6 J	109
Bromodichloromethane	ND (<8.7)	ND (<750)	ND (<0.87)	ND (<2,000)	ND (<0.87)	ND (<1,800)	ND (<0.87)	ND (<45)	ND (<0.74)	ND (<28)	ND (<0.74)	ND (<3.0)	ND (<0.74)	ND (<0.67)
Bromoform	ND (<27)	ND (<720)	ND (<2.7)	ND (<1,900)	ND (<2.7)	ND (<1,700)	ND (<2.7)	ND (<43)	ND (<1.7)	ND (<93)	ND (<1.7)	ND (<10)	ND (<1.7)	ND (<2.2)
Bromomethane	ND (<11)	ND (<610)	ND (<1.1)	ND (<1,600)	ND (<1.1)	ND (<1,500)	ND (<1.1)	ND (<36)	ND (<1.9)	ND (<55)	ND (<1.9)	ND (<5.9)	ND (<1.9)	ND (<1.3)
Carbon disulfide	ND (<10)	ND (<910)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,200)	ND (<1)	ND (<54)	ND (<0.71)	ND (<33)	ND (<0.71)	ND (<3.5)	ND (<0.71)	ND (<0.79)
Carbon tetrachloride	ND (<15)	ND (<1600)	ND (<1.5)	ND (<4,200)	ND (<1.5)	ND (<3,800)	ND (<1.5)	ND (<94)	ND (<0.93)	ND (<28)	ND (<0.93)	ND (<3.0)	ND (<0.93)	ND (<0.67)
Chlorobenzene	ND (<11)	ND (<720)	ND (<1.1)	ND (<1,900)	ND (<1.1)	ND (<1,700)	ND (<1.1)	ND (<43)	ND (<0.93)	ND (<28)	ND (<0.93)	ND (<3.0)	ND (<0.93)	ND (<1.5)
Chloroethane	ND (<28)	ND (<2,900)	ND (<2.8)	ND (<7,600)	ND (<2.8)	ND (<6,900)	ND (<2.8)	ND (<170)	ND (<3.4)	ND (<59)	ND (<3.4)	ND (<6.3)	ND (<3.4)	ND (<1.4)
Chloroform	ND (<11)	ND (<960)	ND (<1.1)	ND (<2,600)	4.4 J	ND (<2,300)	ND (<1.1)	ND (<57)	ND (<1.3)	ND (<45)	ND (<1.3)	ND (<4.8)	ND (<1.3)	ND (<1.1)
Chloromethane	ND (<17)	ND (<760)	ND (<1.7)	ND (<2,000)	5.6	ND (<1,800)	ND (<1.7)	ND (<45)	ND (<1.5)	ND (<59)	ND (<1.5)	ND (<6.4)	ND (<1.5)	ND (<1.4)
cis-1,2-Dichloroethene	ND (<8.9)	ND (<1,100)	ND (<0.89)	ND (<2,900)	ND (<0.89)	ND (<2,700)	ND (<0.89)	ND (<66)	ND (<1.4)	ND (<22)	ND (<1.4)	ND (<2.3)	ND (<1.4)	ND (<0.52)
cis-1,3-Dichloropropene	ND (<7.4)	ND (<680)	ND (<0.74)	ND (<1,800)	ND (<0.74)	ND (<1,700)	ND (<0.74)	ND (<41)	ND (<0.67)	ND (<57)	ND (<0.67)	ND (<6.1)	ND (<0.67)	ND (<1.4)
Cyclohexane	ND (<25)	ND (<2,100)	ND (<2.5)	ND (<5,600)	ND (<2.5)	ND (<5,100)	ND (<2.5)	ND (<130)	ND (<4.3)	ND (<45)	ND (<4.3)	ND (<4.8)	ND (<4.3)	7.5 J
Dibromochloromethane	ND (<9.4)	ND (<910)	ND (<0.94)	ND (<2,400)	ND (<0.94)	ND (<2,200)	ND (<0.94)	ND (<54)	ND (<1.4)	ND (<24)	ND (<1.4)	ND (<2.6)	ND (<1.4)	ND (<0.57)
Dichlorodifluoromethane	ND (<38)	ND (<1,300)	ND (<3.8)	ND (<3,500)	ND (<3.8)	ND (<3,200)	ND (<3.8)	ND (<78)	ND (<5.2)	ND (<46)	ND (<5.2)	ND (<5.0)	ND (<5.2)	ND (<1.1)
Ethylbenzene	600	113,000	15.5	98,500	ND (<1)	44,100	ND (<1)	11,000	6.1	5,640	1.1 J	93.5	ND (<1.0)	68.5
Freon 113	ND (<34)	ND (<1,400)	ND (<3.4)	ND (<3,800)	ND (<3.4)	ND (<3,400)	ND (<3.4)	ND (<84)	ND (<5.9)	ND (<42)	ND (<5.9)	ND (<4.5)	ND (<5.9)	ND (<1)
Isopropylbenzene	16.6 J	30,800	ND (<1)	17,200 J	ND (<1.0)	7,810 J	ND (<1)	2,130	ND (<2.7)	3,540	ND (<2.7)	18.1 J	ND (<2.7)	12.9 J
m,p-Xylene	954	143,000	4.8 J	142,000	ND (<2.1)	69,900	ND (<2.1)	17,400	15.5	12,600	ND (<1.8)	153	ND (<1.8)	102
Methyl Acetate	ND (<100)	ND (<2,300)	ND (<10)	ND (<6,200)	ND (<10)	ND (<5,600)	ND (<10)	ND (<140)	ND (<7.8)	5,740	ND (<7.8)	ND (<38)	ND (<7.8)	ND (<8.4)
Methyl Tert Butyl Ether	ND (<15)	ND (<920)	ND (<1.5)	ND (<2,500)	ND (<1.5)	ND (<2,200)	ND (<1.5)	ND (<55)	ND (<0.98)	ND (<71)	ND (<0.98)	ND (<7.7)	ND (<0.98)	ND (<1.7)
Methylcyclohexane	ND (<9.1)	ND (<1,100)	ND (<0.91)	ND (<2,800)	ND (<0.91)	ND (<2,600)	ND (<0.91)	ND (<63)	ND (<2.5)	ND (<57)	ND (<2.5)	ND (<6.1)	ND (<2.5)	ND (<1.4)
Methylene chloride	ND (<13)	ND (<1,100)	ND (<1.3)	ND (<3,000)	ND (<1.3)	ND (<2,800)	ND (<1.3)	ND (<68)	ND (<1.1)	ND (<53)	ND (<1.1)	ND (<5.7)	ND (<1.1)	ND (<1.3)
o-Xylene	430	67,900	5.0	66,100	ND (<1.5)	30,700	ND (<1.5)	8,470	9.1	6,000	ND (<1.0)	60.1	ND (<1.0)	26.5
Styrene	ND (<7.9)	ND (<540)	ND (<0.79)	ND (<1,400)	ND (<0.79)	ND (<1,300)	ND (<0.79)	ND (<32)	ND (<1.0)	ND (<26)	ND (<1.0)	ND (<2.8)	ND (<1.0)	8.8 J
Tetrachloroethene	ND (<14)	ND (<1,400)	ND (<1.4)	ND (<3,600)	ND (<1.4)	ND (<3,300)	ND (<1.4)	ND (<81)	ND (<1.4)	ND (<38)	ND (<1.4)	ND (<4.1)	ND (<1.4)	ND (<0.90)
Toluene	2,590	76,200	40.2	63,600	5.5	28,100	ND (<1)	6,160	2.9 J	2,720	3.8 J	189	ND (<1.0)	120
trans-1,2-Dichloroethene	ND (<21)	ND (<1,100)	ND (<2.1)	ND (<3,000)	ND (<2.1)	ND (<2,700)	ND (<2.1)	ND (<67)	ND (<1.6)	ND (<63)	ND (<1.6)	ND (<6.7)	ND (<1.6)	ND (<1.5)
trans-1,3-Dichloropropene	ND (<10)	ND (<650)	ND (<1.0)	ND (<1,700)	ND (<1.0)	ND (<1,600)	ND (<1)	ND (<39)	ND (<0.86)	ND (<91)	ND (<0.86)	ND (<9.8)	ND (<0.86)	ND (<2.2)
Trichloroethene	ND (<14)	ND (<860)	ND (<1.4)	ND (<2,300)	ND (<1.4)	ND (<2,100)	ND (<1.4)	ND (<51)	ND (<1.3)	ND (<37)	ND (<1.3)	ND (<3.9)	ND (<1.3)	ND (<0.87)
Trichlorofluoromethane	ND (<13)	ND (<1,200)	ND (<1.3)	ND (<3,200)	ND (<1.3)	ND (<2,900)	ND (<1.3)	ND (<72)	ND (<1.3)	ND (<53)	ND (<1.3)	ND (<5.7)	ND (<1.3)	ND (<1.3)
Vinyl chloride	ND (<14)	ND (<1,100)	ND (<1.4)	ND (<2,800)	ND (<1.4)	ND (<2,600)	ND (<1.4)	ND (<64)	ND (<1.1)	ND (<63)	ND (<1.1)	ND (<6.8)	ND (<1.1)	ND (<1.5)
Xylene (total)	1,380	211,000	9.9	208,000	ND (<1.5)	101,000	ND (<1.5)	25,900	24.5	18,600	ND (<1.0)	213	ND (<1.0)	128
Total TIC, Volatile	22,900 J	2,951,000 J	1,900 J	8,318,000	170 J	4,300,000	88 J	365,000	1,385 J	203,700 J	49 J	16,170 J	ND J	2,468 J
Total Volatiles (Target)	11,501	662,700	167	609,600	34	288,890	3	72,310	840	56,920	381	875	135	751

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Baseline Data		SS-1 Slurry Test Data											
			Persulfate 10:1 (SS1-P-10)		Persulfate 20:1 (SS1-P-20)		Persulfate 40:1 (SS1-P-40)		Fenton 10:1 (SS1-F-10)		Fenton 20:1 (SS1-F-20)		Fenton 40:1 (SS1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Semivolatiles (ug/L or ug/kg)														
1,1'-Biphenyl	144 J	1,110,000	26.6	400,000	7.5	373,000	13	84,700	58.4	502,000	17.0	120,000	5.6	110,000
2,4,5-Trichlorophenol	ND (<1.9)	ND (<4,600)	ND (<1.9)	ND (<410)	ND (<1.9)	ND (<390)	ND (<1.9)	ND (<74)	ND (<1.9)	ND (<4,800)	ND (<1.9)	ND (<2,300)	ND (<1.9)	ND (<480)
2,4,6-Trichlorophenol	ND (<1.3)	ND (<2,600)	ND (<1.3)	ND (<230)	ND (<1.3)	ND (<220)	ND (<1.3)	ND (<42)	ND (<1.3)	ND (<2,700)	ND (<1.3)	ND (<1,300)	ND (<1.3)	ND (<270)
2,4-Dichlorophenol	ND (<1.6)	ND (<5,100)	ND (<1.6)	ND (<460)	ND (<1.6)	ND (<430)	ND (<1.6)	ND (<83)	ND (<1.6)	ND (<5,400)	ND (<1.6)	ND (<2,600)	ND (<1.6)	ND (<540)
2,4-Dimethylphenol	5,350	145,000	ND (<1.6)	ND (<710)	ND (<1.6)	ND (<660)	ND (<1.6)	ND (<130)	ND (<1.6)	ND (<8,200)	3.7 J	ND (<4,000)	ND (<1.6)	2,370
2,4-Dinitrophenol	ND (<0.89)	ND (<4,700)	ND (<0.89)	ND (<420)	ND (<0.89)	ND (<390)	ND (<0.89)	ND (<75)	ND (<0.89)	ND (<4,900)	ND (<0.89)	ND (<2,300)	ND (<0.89)	ND (<490)
2,4-Dinitrotoluene	ND (<0.86)	ND (<3,600)	ND (<0.86)	ND (<320)	ND (<0.86)	ND (<300)	ND (<0.86)	ND (<57)	ND (<0.86)	ND (<3,700)	ND (<0.86)	ND (<1,800)	ND (<0.86)	ND (<1,700)
2,6-Dinitrotoluene	ND (<0.56)	ND (<3,500)	ND (<0.56)	ND (<310)	ND (<0.56)	ND (<300)	ND (<0.56)	ND (<56)	ND (<0.56)	ND (<3,700)	ND (<0.56)	ND (<1,800)	ND (<0.56)	ND (<1,700)
2-Chloronaphthalene	ND (<0.98)	ND (<4,300)	ND (<0.98)	ND (<390)	ND (<0.98)	ND (<360)	ND (<0.98)	ND (<69)	ND (<0.98)	ND (<4,500)	ND (<0.98)	ND (<2,200)	ND (<0.98)	ND (<2,100)
2-Chlorophenol	ND (<0.95)	ND (<2,600)	ND (<0.95)	ND (<240)	ND (<0.95)	ND (<220)	ND (<0.95)	ND (<42)	ND (<0.95)	ND (<2,700)	ND (<0.95)	ND (<1,300)	ND (<0.95)	ND (<270)
2-Methylnaphthalene	983	5,720,000	29.9	2,450,000	9.6	2,080,000	16.4	486,000	231	1,730,000	17.8	232,000	2.7	61,300
2-Methylphenol	3,290	26,200	ND (<1.4)	ND (<270)	ND (<1.4)	ND (<250)	ND (<1.4)	ND (<49)	ND (<1.4)	ND (<3,100)	5.0	1,660 J	ND (<1.4)	1,600
2-Nitroaniline	ND (<0.66)	ND (<1,900)	ND (<0.66)	ND (<170)	ND (<0.66)	ND (<160)	ND (<0.66)	ND (<31)	ND (<0.66)	ND (<2,000)	ND (<0.66)	ND (<980)	ND (<0.66)	ND (<940)
2-Nitrophenol	ND (<1.8)	ND (<3,800)	ND (<1.8)	ND (<340)	ND (<1.8)	ND (<320)	ND (<1.8)	ND (<61)	ND (<1.8)	ND (<4,000)	ND (<1.8)	ND (<1,900)	ND (<1.8)	ND (<400)
3&4-Methylphenol	3,990	ND (<4,400)	ND (<1.3)	ND (<390)	ND (<1.3)	ND (<370)	ND (<1.3)	ND (<71)	ND (<1.3)	ND (<4,600)	12.8	3,780 J	2.0 J	4,640
3,3'-Dichlorobenzidine	ND (<1.2)	ND (<2,900)	ND (<1.2)	ND (<260)	ND (<1.2)	ND (<250)	ND (<1.2)	ND (<47)	ND (<1.2)	ND (<3,100)	ND (<1.2)	ND (<1,500)	ND (<1.2)	ND (<1,400)
3-Nitroaniline	ND (<1.3)	ND (<2,400)	ND (<1.3)	ND (<210)	ND (<1.3)	ND (<200)	ND (<1.3)	ND (<38)	ND (<1.3)	ND (<2,500)	ND (<1.3)	ND (<1,200)	ND (<1.3)	ND (<1,200)
4,6-Dinitro-o-cresol	ND (<0.72)	ND (<2,700)	ND (<0.72)	ND (<240)	ND (<0.72)	ND (<230)	ND (<0.72)	ND (<43)	ND (<0.72)	ND (<2,800)	ND (<0.72)	ND (<1,300)	ND (<0.72)	ND (<280)
4-Bromophenyl phenyl ether	ND (<0.3)	ND (<1,600)	ND (<0.3)	ND (<140)	ND (<0.3)	ND (<130)	ND (<0.30)	ND (<25)	ND (<0.30)	ND (<1,600)	ND (<0.30)	ND (<790)	ND (<0.3)	ND (<750)
4-Chloro-3-methyl phenol	ND (<1.2)	ND (<3,900)	ND (<1.2)	ND (<350)	ND (<1.2)	ND (<330)	ND (<1.2)	ND (<63)	ND (<1.2)	ND (<4,100)	ND (<1.2)	ND (<2,000)	ND (<1.2)	ND (<410)
4-Chloroaniline	ND (<0.4)	ND (<1,900)	ND (<0.4)	ND (<170)	ND (<0.4)	ND (<160)	ND (<0.40)	ND (<31)	ND (<0.40)	ND (<2,000)	ND (<0.40)	ND (<960)	ND (<0.4)	ND (<920)
4-Chlorophenyl phenyl ether	ND (<0.43)	ND (<1,400)	ND (<0.43)	ND (<130)	ND (<0.43)	ND (<120)	ND (<0.43)	ND (<23)	ND (<0.43)	ND (<1,500)	ND (<0.43)	ND (<730)	ND (<0.43)	ND (<700)
4-Nitroaniline	ND (<0.72)	ND (<2,100)	ND (<0.72)	ND (<190)	ND (<0.72)	ND (<180)	ND (<0.72)	ND (<34)	ND (<0.72)	ND (<2,200)	ND (<0.72)	ND (<1,100)	ND (<0.72)	ND (<1,000)
4-Nitrophenol	ND (<0.84)	ND (<4,200)	ND (<0.84)	ND (<370)	ND (<0.84)	ND (<350)	ND (<0.84)	ND (<67)	ND (<0.84)	ND (<4,400)	ND (<0.84)	ND (<2,100)	ND (<0.84)	ND (<440)
Acenaphthene	299	3,300,000	1.3 J	1,070,000	4.3	829,000	3	181,000	94.1	1,260,000	31.5	412,000	3.61	120,000
Acenaphthylene	168 J	155,000	7.9	29,600	0.63 J	30,700	1.1 J	8,850	4.0	77,500	1.73	57,700	0.936	84,200
Acetophenone	ND (<0.37)	ND (<1,900)	19.9	ND (<170)	2.7 J	ND (<160)	7	ND (<31)	3.4 J	ND (<2,000)	ND (<0.37)	ND (<980)	ND (<0.37)	1,500 J
Anthracene	252	2,330,000	7.4	757,000	2.9	527,000	2.8	76,200	15.5	889,000	8.6	335,000	1.64	97,300
Atrazine	ND (<0.16)	ND (<2,700)	ND (<0.16)	ND (<240)	ND (<0.16)	ND (<220)	ND (<0.16)	ND (<43)	ND (<0.16)	ND (<2,800)	ND (<0.16)	ND (<1,300)	ND (<0.16)	ND (<1,300)
Benzaldehyde	ND (<0.27)	ND (<3,400)	13.1	ND (<300)	3.9 J	ND (<290)	6.7	ND (<54)	ND (<0.27)	ND (<3,500)	5.5	ND (<1,700)	ND (<0.27)	ND (<1,600)
Benzo(a)anthracene	147 J	1,560,000	14.6	541,000	4.2	506,000	10.4	90,800	22.0	863,000	26.2	1,190,000	6.2	627,000
Benzo(a)pyrene	102 J	1,110,000	3.2	432,000	2.4	357,000	3.9	48,900	12.8	689,000	15.6	733,000	1.96	258,000
Benzo(b)fluoranthene	97.1	970,000	13.7	452,000	3.7	341,000	10.1	68,100	17.5	640,000	20.7	971,000	3.36	619,000
Benzo(g,h,i)perylene	85.5	618,000	7.1	157,000	2.3	176,000	5.5	34,500	5.1	288,000	9.7	437,000	1.23	179,000
Benzo(k)fluoranthene	88.4 J	733,000	12	206,000	2.9	246,000	9.1	40,200	16.9	599,000	14.7	664,000	3.4	368,000
bis(2-Chloroethoxy)methane	ND (<0.65)	ND (<2,000)	ND (<0.65)	ND (<180)	ND (<0.65)	ND (<170)	ND (<0.65)	ND (<32)	ND (<0.65)	ND (<2,100)	ND (<0.65)	ND (<1,000)	ND (<0.65)	ND (<960)
bis(2-Chloroethyl)ether	ND (<0.53)	ND (<1,500)	ND (<0.53)	ND (<140)	ND (<0.53)	ND (<130)	ND (<0.53)	ND (<25)	ND (<0.53)	ND (<1,600)	ND (<0.53)	ND (<770)	ND (<0.53)	ND (<740)
bis(2-Chloroisopropyl)ether	ND (<0.74)	ND (<2,300)	ND (<0.74)	ND (<210)	ND (<0.74)	ND (<190)	ND (<0.74)	ND (<37)	ND (<0.74)	ND (<2,400)	ND (<0.74)	ND (<1,200)	ND (<0.74)	ND (<1,100)
bis(2-Ethylhexyl)phthalate	ND (<0.66)	ND (<3,900)	ND (<0.66)	ND (<350)	1.3 J	ND (<330)	ND (<0.66)	931	ND (<0.66)	ND (<4,100)	ND (<0.66)	ND (<2,000)	ND (<0.66)	4,940
Butyl benzyl phthalate	ND (<0.59)	ND (<2,300)	ND (<0.59)	ND (<210)	ND (<0.59)	ND (<200)	ND (<0.59)	ND (<37)	ND (<0.59)	ND (<2,400)	ND (<0.59)	ND (<1,200)	ND (<0.59)	ND (<1,100)
Caprolactam	ND (<0.32)	ND (<3,000)	ND (<0.32)	ND (<270)	ND (<0.32)	ND (<250)	ND (<0.32)	ND (<48)	ND (<0.32)	ND (<3,100)	ND (<0.32)	ND (<1,500)	ND (<0.32)	ND (<1,400)
Carbazole	297	831,000	10.2	104,000	0.54 J	29,300	1.5 J	4,320	36.4	188,000	4.1	35,300	0.51 J	25,900
Chrysene	139 J	1,670,000	25.8	549,000	5.4	524,000	15.1	95,300	27.4	963,000	28.5	1,280,000	8.5	888,000
Dibenzo(a,h)anthracene	23.5	159,000	2.3	68,600	ND (<0.54)	72,700	1.4 J	14,300	2.2	135,000	4.4	130,000	0.868	109,000
Dibenzofuran	297 J	2,360,000	51.5	907,000	14.4	808,000	28.6	178,000	88.2	1,100,000	42.8	553,000	11.0	262,000
Diethyl phthalate	ND (<0.39)	ND (<1,300)	ND (<0.39)	ND (<120)	ND (<0.39)	ND (<110)	ND (<0.39)	ND (<21)	ND (<0.39)	ND (<1,400)	ND (<0.39)	ND (<660)	ND (<0.39)	ND (<640)
Dimethyl phthalate	ND (<0.33)	ND (<1,300)	ND (<0.33)	ND (<120)	ND (<0.33)	ND (<110)	ND (<0.33)	ND (<21)	ND (<0.33)	ND (<1,400)	ND (<0.33)	ND (<660)	ND (<0.33)	ND (<640)
Di-n-butyl phthalate	ND (<0.59)	ND (<2,000)	ND (<0.59)	ND (<180)	ND (<0.59)	ND (<170)	ND (<0.59)	ND (<32)	ND (<0.59)	ND (<2,000)	ND (<0.59)	ND (<980)	ND (<0.59)	ND (<940)
Di-n-octyl phthalate	ND (<0.57)	ND (<2,600)	ND (<0.57)	ND (<240)	ND (<0.57)	ND (<220)	ND (<0.57)	ND (<42)	ND (<0.57)	ND (<2,700)	ND (<0.57)	ND (<1,300)	ND (<0.57)	ND (<1,300)
Fluoranthene	509	4,820,000	65.8	1,620,000	15.3	1,460,000	43.5	281,000	78.3	2,610,000	87.4	3,530,000	21.7	1,930,000
Fluorene	320	2,680,000	7.5	892,000	4.7	641,000	12.1	147,000	135	1,560,000	96.6	1,360,000	23.4	673,000

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Baseline Data		SS-1 Slurry Test Data											
	Groundwater	Soil	Persulfate 10:1 (SS1-P-10)		Persulfate 20:1 (SS1-P-20)		Persulfate 40:1 (SS1-P-40)		Fenton 10:1 (SS1-F-10)		Fenton 20:1 (SS1-F-20)		Fenton 40:1 (SS1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L, unless noted)														
Solids, Percent		81.5		72.6		77.0		67.3		62.3		64.7		61.2
Chromium, Hexavalent	ND (<0.010)				ND (<0.10) c						0.071			
Iron, Ferrous	0.36				0.11						101			
Nitrogen, Nitrate ^a	ND (<0.11)				51.6						1.4			
Nitrogen, Nitrate + Nitrite	ND (<0.10)				51.7						1.4			
Nitrogen, Nitrite	ND (<0.010)				0.11						ND (<0.010)			
Petroleum Hydrocarbons	5.3	1,970		3,620	ND (<0.53) d	2,210		347		4,430	0.51	2,360		291
Phosphorus, Total	0.32				ND (<0.050) d						50.8			
Sulfate	ND (<10)				62,100						1,750			
Total Organic Carbon	92.9	537,000	414	303,000	808	192,000	2,020	24,700	1,060	471,000	1,070	554,000	898	519,000
pH, standard units	7.20 b		13.18 b		13.42 b		12.94 b		2.14 b		2.19 b		2.21 b	
As(III) (ug/L)	7.5				ND (<0.56)						ND (<1.23)			
As(V) (ug/L)	3.0				658						752			
Metals (ug/L or mg/kg)														
Arsenic	20.6	20.6	499	7.5	683	4.9	385	ND (<3.0)	459	16.1	558	14.9	590	16.0
Barium	ND (<200)	89.8	ND (<2,000) c	37.0	ND (<2,000) c	25.8	ND (<400) c	ND (<30)	364	79.7	456	95.5	191 B	97.5
Cadmium	ND (<4.0)	1.4	ND (<40) c	ND (<0.68)	ND (<40) c	ND (<0.62)	ND (<8.0) c	ND (<0.74)	25.5	ND (<0.77)	31.8	ND (<0.22)	58.8	ND (<0.22)
Chromium	ND (<10)	11.7	128	3.7	193	2.3	90.2	ND (<1.5)	140	7.9	4,690	1,420	6,990	1,710
Iron	1,280	19,600	ND (<1,000) c	6,820	1,260	5,470	292	704	557,000	9,590	833,000	16,300	900,000	18200
Lead	ND (<3.0)	91.1	1,700	51.0	5,600	25.5	2,690	8.4	2,920	106	3,070	139	5,280	272
Manganese	79.8		ND (<150) c	53.0	ND (<150) c	38.9	ND (<30) c	8.3	3,690	55.7	6,270	209	9,320	236
Mercury	ND (<0.40) c	0.17	ND (<0.20)	0.087	0.95	0.045	0.92	0.051	ND (<0.20)	0.47	ND (<0.20)	0.92	0.065 B	0.88
Selenium	ND (<10)	3.3	ND (<100) c	ND (<2.7)	160	ND (<2.5)	36.1	ND (<3.0)	57.2	ND (<3.1)	93.0	1.6 B	123	ND (<1.2)
Silver	ND (<10)	ND (<1.2)	ND (<100) c	ND (<1.4)	ND (<100) c	ND (<1.2)	ND (<20) c	ND (<1.5)	ND (<10)	ND (<1.5)	12.9	ND (<0.23)	2.4 B	0.47 B
Thallium	ND (<10)	ND (<1.2)	ND (<100) c	ND (<1.4)	ND (<100) c	ND (<1.2)	ND (<20) c	ND (<1.5)	ND (<10)	ND (<1.5)	ND (<10)	ND (<1.2)	10.5	ND (<1.3)

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Column Test Data		SS-1 Autoclave Test Data							
	Persulfate	Fenton	Fenton Autoclave				Persulfate Autoclave			
	Soil	Soil	Leachate	Soil	Silica Gel	Carbon	Leachate	Soil	Silica Gel	Carbon
Volatiles (ug/L or ug/kg)										
1,1,1-Trichloroethane	ND (<2,800)	ND (<2,800)	ND (<0.3)	ND (<2.8)	2.8 J	104 J	ND (<3.0)	ND (<360)	3.1 J	101 J
1,1,2,2-Tetrachloroethane	ND (<2,200)	ND (<2,200)	ND (<0.8)	ND (<2.2)	ND (<0.34)	ND (<34)	ND (<8.0)	ND (<280)	ND (<0.34)	ND (<35)
1,1,2-Trichloroethane	ND (<2,200)	ND (<2,200)	ND (<0.49)	ND (<2.2)	ND (<0.34)	ND (<34)	ND (<4.9)	ND (<280)	ND (<0.34)	ND (<35)
1,1-Dichloroethane	ND (<5,100)	ND (<5,100)	ND (<0.2)	ND (<5.2)	ND (<0.81)	ND (<79)	ND (<2.0)	ND (<660)	ND (<0.79)	ND (<83)
1,1-Dichloroethene	ND (<3,400)	ND (<3,400)	ND (<0.28)	ND (<3.5)	0.71 J	ND (<53)	ND (<2.8)	ND (<440)	0.92 J	ND (<56)
1,2,4-Trichlorobenzene	ND (<2,600)	ND (<2,600)	ND (<0.41)	ND (<2.7)	ND (<0.41)	ND (<41)	ND (<4.1)	ND (<340)	ND (<0.41)	ND (<42)
1,2-Dibromo-3-chloropropane	ND (<6,900)	ND (<6,900)	ND (<0.8)	ND (<7)	ND (<1.1)	ND (<110)	ND (<8.0)	ND (<900)	ND (<1.1)	ND (<110)
1,2-Dibromoethane	ND (<2,100)	ND (<2,100)	ND (<0.45)	ND (<2.2)	ND (<0.34)	ND (<34)	ND (<4.5)	ND (<280)	ND (<0.34)	ND (<35)
1,2-Dichlorobenzene	ND (<2,000)	ND (<2,000)	ND (<0.2)	ND (<2.1)	ND (<0.32)	ND (<32)	ND (<2.0)	ND (<270)	ND (<0.32)	ND (<33)
1,2-Dichloroethane	ND (<1,700)	ND (<1,700)	ND (<0.29)	ND (<1.8)	ND (<0.28)	74 J	ND (<2.9)	ND (<230)	ND (<0.27)	70 J
1,2-Dichloropropane	ND (<3,000)	ND (<3,000)	ND (<0.24)	ND (<3.1)	ND (<0.48)	ND (<47)	ND (<2.4)	ND (<400)	ND (<0.47)	ND (<49)
1,3-Dichlorobenzene	ND (<2,700)	ND (<2,700)	ND (<0.21)	ND (<2.8)	ND (<0.43)	ND (<42)	ND (<2.1)	ND (<350)	ND (<0.42)	ND (<44)
1,4-Dichlorobenzene	ND (<2,200)	ND (<2,200)	ND (<0.17)	ND (<2.3)	ND (<0.35)	ND (<34)	ND (<1.7)	ND (<290)	ND (<0.34)	ND (<36)
2-Butanone (MEK)	ND (<21,000)	ND (<21,000)	ND (<2.7)	ND (<21)	ND (<3.3)	ND (<320)	38.5 J	ND (<2,700)	ND (<3.2)	ND (<340)
2-Hexanone	ND (<13,000)	ND (<13,000)	ND (<0.94)	ND (<13)	ND (<2)	ND (<200)	ND (<9.4)	ND (<1,700)	ND (<2)	ND (<210)
4-Methyl-2-pentanone(MIBK)	ND (<15,000)	ND (<15,000)	ND (<1.4)	ND (<15)	ND (<2.3)	ND (<230)	ND (<14)	ND (<1,900)	ND (<2.3)	ND (<240)
Acetone	ND (<30,000)	ND (<30,000)	117	ND (<31)	94.4	ND (<470)	1140	ND (<3,900)	72.9	ND (<490)
Benzene	6,540	ND (<5,400)	1.6	14.8	5.4	ND (<83)	12.8	2,730	9.8	ND (<87)
Bromodichloromethane	ND (<1,800)	ND (<1,800)	ND (<0.15)	ND (<1.9)	ND (<0.29)	ND (<29)	ND (<1.5)	ND (<240)	ND (<0.29)	ND (<30)
Bromoform	ND (<6,000)	ND (<6,000)	ND (<0.34)	ND (<6.2)	ND (<0.95)	ND (<94)	ND (<3.4)	ND (<790)	ND (<0.94)	ND (<98)
Bromomethane	ND (<3,600)	ND (<3,600)	ND (<0.38)	ND (<3.7)	ND (<0.57)	ND (<56)	ND (<3.8)	ND (<470)	ND (<0.56)	ND (<58)
Carbon disulfide	ND (<2,100)	ND (<2,100)	0.58 J	ND (<2.2)	ND (<0.34)	ND (<33)	16.5 J	ND (<280)	ND (<0.33)	ND (<35)
Carbon tetrachloride	ND (<1,800)	ND (<1,800)	ND (<0.19)	ND (<1.9)	ND (<0.29)	ND (<29)	ND (<1.9)	ND (<240)	ND (<0.29)	ND (<30)
Chlorobenzene	ND (<4,100)	ND (<4,100)	ND (<0.19)	ND (<4.2)	ND (<0.65)	ND (<64)	ND (<1.9)	ND (<540)	ND (<0.64)	ND (<67)
Chloroethane	ND (<3,800)	ND (<3,800)	ND (<0.67)	ND (<3.9)	ND (<0.61)	ND (<60)	ND (<6.7)	ND (<500)	ND (<0.6)	ND (<62)
Chloroform	ND (<2,900)	ND (<2,900)	ND (<0.25)	ND (<3)	0.89 J	296 J	ND (<2.5)	ND (<380)	0.96 J	268 J
Chloromethane	ND (<3,900)	ND (<3,900)	ND (<0.3)	ND (<4)	ND (<0.61)	ND (<60)	50.5	ND (<500)	ND (<0.6)	ND (<63)
cis-1,2-Dichloroethene	ND (<1,400)	ND (<1,400)	ND (<0.27)	ND (<1.4)	ND (<0.22)	ND (<22)	ND (<2.7)	ND (<180)	ND (<0.22)	ND (<23)
cis-1,3-Dichloropropene	ND (<3,700)	ND (<3,700)	ND (<0.13)	ND (<3.8)	ND (<0.58)	ND (<58)	ND (<1.3)	ND (<480)	ND (<0.58)	ND (<60)
Cyclohexane	ND (<2,900)	ND (<2,900)	ND (<0.85)	ND (<3)	ND (<0.46)	ND (<45)	ND (<8.5)	ND (<380)	ND (<0.45)	ND (<47)
Dibromochloromethane	ND (<1,500)	ND (<1,500)	ND (<0.28)	ND (<1.6)	ND (<0.24)	ND (<24)	ND (<2.8)	ND (<200)	ND (<0.24)	ND (<25)
Dichlorodifluoromethane	ND (<3,000)	ND (<3,000)	ND (<1)	ND (<3.1)	ND (<0.47)	ND (<47)	ND (<10)	ND (<390)	ND (<0.47)	ND (<49)
Ethylbenzene	81,000	8,250	0.54 J	23.9	2.1	ND (<56)	ND (<2.1)	20,800	9.5	ND (<58)
Freon 113	ND (<2,700)	ND (<2,700)	ND (<1.2)	ND (<2.8)	ND (<0.43)	101 J	ND (<12)	ND (<360)	4.5 J	ND (<45)
Isopropylbenzene	24,600	3,670	ND (<0.54)	3.9 J	ND (<0.35)	ND (<34)	ND (<5.4)	4,470 J	0.65 J	ND (<36)
m,p-Xylene	275,000	31,500	1.4	74.7	8.3	ND (<56)	ND (<3.5)	70,500	35.7	ND (<59)
Methyl Acetate	ND (<23,000)	ND (<23,000)	ND (<1.6)	ND (<23)	ND (<3.6)	ND (<360)	ND (<16)	ND (<3,000)	ND (<3.6)	ND (<370)
Methyl Tert Butyl Ether	ND (<4,600)	ND (<4,700)	ND (<0.2)	ND (<4.7)	2.0	ND (<72)	ND (<2.0)	ND (<600)	2.1	ND (<76)
Methylcyclohexane	ND (<3,700)	ND (<3,700)	ND (<0.5)	ND (<3.8)	0.91 J	ND (<58)	ND (<5.0)	ND (<480)	1.5 J	ND (<60)
Methylene chloride	ND (<3,500)	ND (<3,500)	ND (<0.21)	ND (<3.5)	11.3	1,070	ND (<2.1)	ND (<450)	13.8	946
o-Xylene	136,000	14,900	0.50 J	35	3.0	ND (<30)	ND (<2.0)	37,600	9.4	ND (<31)
Styrene	ND (<1,700)	ND (<1,700)	ND (<0.2)	ND (<1.7)	ND (<0.27)	ND (<26)	ND (<2.0)	ND (<220)	ND (<0.26)	ND (<27)
Tetrachloroethene	ND (<2,400)	ND (<2,500)	ND (<0.28)	ND (<2.5)	2.2 J	ND (<38)	ND (<2.8)	ND (<320)	2.6 J	ND (<40)
Toluene	57,500	ND (<3,100)	2.3	34.2	20.4	ND (<48)	ND (<2.1)	19,100	34.4	ND (<50)
trans-1,2-Dichloroethene	ND (<4,100)	ND (<4,100)	ND (<0.32)	ND (<4.2)	ND (<0.65)	ND (<64)	ND (<3.2)	ND (<530)	ND (<0.64)	ND (<66)
trans-1,3-Dichloropropene	ND (<5,900)	ND (<6,000)	ND (<0.17)	ND (<6.1)	ND (<0.94)	ND (<93)	ND (<1.7)	ND (<770)	ND (<0.93)	ND (<97)
Trichloroethene	ND (<2,400)	ND (<2,400)	ND (<0.26)	ND (<2.4)	1.9 J	ND (<37)	ND (<2.6)	ND (<310)	2.1 J	ND (<39)
Trichlorofluoromethane	ND (<3,400)	ND (<3,500)	ND (<0.26)	ND (<3.5)	17.6	168 J	ND (<2.6)	ND (<450)	20.1	155 J
Vinyl chloride	ND (<4,100)	ND (<4,100)	ND (<0.22)	ND (<4.2)	ND (<0.65)	ND (<64)	ND (<2.2)	ND (<530)	ND (<0.64)	ND (<67)
Xylene (total)	410,000	46,400	1.9	110	11.3	ND (<30)	ND (<2.0)	108,000	45.1	ND (<31)
Total TIC, Volatile	7,210,000	1,104,000	21 J	2,355 J	37.9 J	1,220 J	ND	1,736,000 J	433.1 J	1,230 J
Total Volatiles (Target)	990,640	104,720	125.82	296.5	185.21	1,813	1258.3	263,200	269.13	1,540

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Column Test Data		SS-1 Autoclave Test Data							
	Persulfate	Fenton	Fenton Autoclave				Persulfate Autoclave			
	Soil	Soil	Leachate	Soil	Silica Gel	Carbon	Leachate	Soil	Silica Gel	Carbon
Semivolatiles (ug/L or ug/kg)										
1,1'-Biphenyl	443,000	142,000	6.2	10,000	ND (<100)	ND (<100)	28.3	415,000	ND (<100)	ND (<260)
2,4,5-Trichlorophenol	ND (<1,900)	ND (<1,900)	ND (<1.9)	ND (<360)	ND (<320)	ND (<310)	ND (<1.9)	ND (<940)	ND (<320)	ND (<810)
2,4,6-Trichlorophenol	ND (<1,100)	ND (<1,000)	ND (<1.3)	ND (<200)	ND (<180)	ND (<180)	ND (<1.3)	ND (<520)	ND (<180)	ND (<460)
2,4-Dichlorophenol	ND (<2,100)	ND (<2,100)	ND (<1.6)	ND (<400)	ND (<360)	ND (<350)	ND (<1.6)	ND (<1,000)	ND (<350)	ND (<910)
2,4-Dimethylphenol	ND (<3,300)	ND (<3,200)	1.9 J	ND (<610)	ND (<550)	ND (<540)	ND (<1.6)	ND (<1,600)	ND (<540)	ND (<1,400)
2,4-Dinitrophenol	ND (<1,900)	ND (<1,900)	ND (<0.89)	ND (<360)	ND (<330)	ND (<320)	ND (<0.89)	ND (<950)	ND (<320)	ND (<820)
2,4-Dinitrotoluene	ND (<1,500)	ND (<1,400)	ND (<0.86)	ND (<280)	ND (<250)	ND (<240)	ND (<0.86)	ND (<720)	ND (<250)	ND (<630)
2,6-Dinitrotoluene	ND (<1,500)	ND (<1,400)	ND (<0.56)	ND (<270)	ND (<240)	ND (<240)	ND (<0.56)	ND (<710)	ND (<240)	ND (<620)
2-Chloronaphthalene	ND (<1,800)	ND (<1,700)	ND (<0.98)	ND (<330)	ND (<300)	ND (<290)	ND (<0.98)	ND (<870)	ND (<300)	ND (<760)
2-Chlorophenol	ND (<1,100)	ND (<1,100)	ND (<0.95)	ND (<200)	ND (<180)	ND (<180)	ND (<0.95)	ND (<530)	ND (<180)	ND (<460)
2-Methylnaphthalene	2,670,000	982,000	11.4	39,900	ND (<140)	ND (<140)	119	1,880,000	551	ND (<350)
2-Methylphenol	ND (<1,300)	ND (<1,200)	2.6 J	ND (<230)	ND (<210)	ND (<210)	ND (<1.4)	ND (<610)	ND (<210)	ND (<530)
2-Nitroaniline	ND (<810)	ND (<780)	ND (<0.66)	ND (<150)	ND (<140)	ND (<130)	ND (<0.66)	ND (<390)	ND (<130)	ND (<340)
2-Nitrophenol	ND (<1,600)	ND (<1,500)	ND (<1.8)	ND (<300)	ND (<270)	ND (<260)	ND (<1.8)	ND (<770)	ND (<260)	ND (<670)
3&4-Methylphenol	ND (<1,800)	ND (<1,800)	6.3	ND (<340)	ND (<310)	ND (<300)	ND (<1.3)	ND (<890)	ND (<300)	ND (<780)
3,3'-Dichlorobenzidine	ND (<1,200)	ND (<1,200)	ND (<1.2)	ND (<230)	ND (<200)	ND (<200)	ND (<1.2)	ND (<600)	ND (<200)	ND (<520)
3-Nitroaniline	ND (<990)	ND (<960)	ND (<1.3)	ND (<190)	ND (<170)	ND (<160)	ND (<1.3)	ND (<480)	ND (<160)	ND (<420)
4,6-Dinitro-o-cresol	ND (<1,100)	ND (<1,100)	ND (<0.72)	ND (<210)	ND (<190)	ND (<180)	ND (<0.72)	ND (<540)	ND (<180)	ND (<470)
4-Bromophenyl phenyl ether	ND (<650)	ND (<630)	ND (<0.3)	ND (<120)	ND (<110)	ND (<110)	ND (<0.3)	ND (<320)	ND (<110)	ND (<280)
4-Chloro-3-methyl phenol	ND (<1,600)	ND (<1,600)	ND (<1.2)	ND (<300)	ND (<270)	ND (<270)	ND (<1.2)	ND (<790)	ND (<270)	ND (<690)
4-Chloroaniline	ND (<790)	ND (<770)	ND (<0.4)	ND (<150)	ND (<130)	ND (<130)	ND (<0.4)	ND (<390)	ND (<130)	ND (<340)
4-Chlorophenyl phenyl ether	ND (<600)	ND (<580)	ND (<0.43)	ND (<110)	ND (<100)	ND (<98)	ND (<0.43)	ND (<290)	ND (<99)	ND (<250)
4-Nitroaniline	ND (<880)	ND (<850)	ND (<0.72)	ND (<160)	ND (<150)	ND (<140)	ND (<0.72)	ND (<430)	ND (<150)	ND (<370)
4-Nitrophenol	ND (<1,700)	ND (<1,700)	ND (<0.84)	ND (<330)	ND (<290)	ND (<280)	ND (<0.84)	ND (<850)	ND (<290)	ND (<740)
Acenaphthene	1,520,000	719,000	13.4	32,900	ND (<110)	ND (<110)	2.02	1,120,000	296 J	ND (<280)
Acenaphthylene	74,200	39,900	1.5	4,460	ND (<87)	ND (<85)	2.27	75,100	ND (<86)	ND (<220)
Acetophenone	ND (<810)	ND (<780)	2.7 J	ND (<150)	ND (<130)	ND (<130)	60.3	ND (<390)	ND (<130)	ND (<340)
Anthracene	1,040,000	461,000	10.2	28,700	ND (<83)	ND (<81)	6.70	693,000	ND (<82)	ND (<210)
Atrazine	ND (<1,100)	ND (<1,100)	ND (<0.16)	ND (<210)	ND (<180)	ND (<180)	ND (<0.16)	ND (<540)	ND (<180)	ND (<470)
Benzaldehyde	ND (<1,400)	ND (<1,400)	3.0 J	ND (<260)	ND (<240)	ND (<230)	43.7	ND (<690)	ND (<230)	ND (<600)
Benzo(a)anthracene	732,000	369,000	35.8	55,300	ND (<100)	ND (<100)	21.9	542,000	ND (<100)	ND (<260)
Benzo(a)pyrene	552,000	270,000	17.0	39,600	ND (<74)	ND (<73)	3.90	374,000	ND (<74)	ND (<190)
Benzo(b)fluoranthene	545,000	256,000	21.4	41,700	ND (<98)	ND (<95)	25.9	305,000	ND (<96)	ND (<250)
Benzo(g,h,i)perylene	215,000	122,000	7.7	20,900	ND (<120)	ND (<110)	11.8	290,000	ND (<120)	ND (<300)
Benzo(k)fluoranthene	499,000	269,000	18.7	23,400	ND (<160)	ND (<160)	22.1	400,000	ND (<160)	ND (<410)
bis(2-Chloroethoxy)methane	ND (<830)	ND (<800)	ND (<0.65)	ND (<150)	ND (<140)	ND (<130)	ND (<0.65)	ND (<400)	ND (<140)	ND (<350)
bis(2-Chloroethyl)ether	ND (<640)	ND (<620)	ND (<0.53)	ND (<120)	ND (<110)	ND (<100)	ND (<0.53)	ND (<310)	ND (<110)	ND (<270)
bis(2-Chloroisopropyl)ether	ND (<960)	ND (<930)	ND (<0.74)	ND (<180)	ND (<160)	ND (<160)	ND (<0.74)	ND (<470)	ND (<160)	ND (<410)
bis(2-Ethylhexyl)phthalate	6,570	ND (<1,600)	ND (<0.66)	ND (<310)	592	ND (<270)	ND (<0.66)	2,030	ND (<270)	788 J
Butyl benzyl phthalate	ND (<970)	ND (<930)	ND (<0.59)	ND (<180)	ND (<160)	ND (<160)	ND (<0.59)	ND (<470)	ND (<160)	ND (<410)
Caprolactam	ND (<1,200)	ND (<1,200)	ND (<0.32)	ND (<230)	ND (<210)	ND (<200)	ND (<0.32)	ND (<600)	ND (<200)	ND (<520)
Carbazole	192,000	80,400	2.1	5,460	ND (<86)	ND (<85)	6.70	160,000	ND (<85)	ND (<220)
Chrysene	732,000	375,000	41.2	58,700	ND (<79)	ND (<77)	42.8	511,000	ND (<78)	ND (<200)
Dibenzo(a,h)anthracene	114,000	58,900	2.93	10,500	ND (<110)	ND (<110)	3.50	115,000	ND (<110)	ND (<280)
Dibenzofuran	1,270,000	586,000	15.6	24,100	ND (<99)	ND (<97)	110	777,000	393 J	ND (<250)
Diethyl phthalate	ND (<550)	ND (<530)	ND (<0.39)	ND (<100)	ND (<92)	ND (<90)	ND (<0.39)	ND (<270)	ND (<90)	ND (<230)
Dimethyl phthalate	ND (<550)	ND (<530)	ND (<0.33)	ND (<100)	ND (<92)	ND (<90)	ND (<0.33)	ND (<270)	ND (<91)	ND (<230)
Di-n-butyl phthalate	ND (<820)	ND (<790)	ND (<0.59)	ND (<150)	ND (<140)	ND (<130)	ND (<0.59)	ND (<400)	ND (<130)	ND (<340)
Di-n-octyl phthalate	ND (<1,100)	ND (<1,100)	ND (<0.57)	ND (<200)	ND (<180)	ND (<180)	ND (<0.57)	ND (<530)	ND (<180)	ND (<460)
Fluoranthene	1,970,000	1,020,000	117 E	154,000	ND (<76)	ND (<74)	144	1,650,000	117 J	676 J
Fluorene	1,460,000	781,000	55.3	51,800	ND (<86)	ND (<84)	60.3	956,000	276 J	ND (<220)
Hexachlorobenzene	ND (<740)	ND (<710)	ND (<0.02)	ND (<140)	ND (<120)	ND (<120)	ND (<0.02)	ND (<360)	ND (<120)	ND (<310)
Hexachlorobutadiene	ND (<840)	ND (<810)	ND (<0.18)	ND (<160)	ND (<140)	ND (<140)	ND (<0.18)	ND (<410)	ND (<140)	ND (<360)
Hexachlorocyclopentadiene	ND (<920)	ND (<890)	ND (<0.41)	ND (<170)	ND (<150)	ND (<150)	ND (<0.41)	ND (<450)	ND (<150)	ND (<390)
Hexachloroethane	ND (<640)	ND (<620)	ND (<0.28)	ND (<120)	ND (<110)	ND (<100)	ND (<0.28)	ND (<310)	ND (<110)	ND (<270)
Indeno(1,2,3-cd)pyrene	280,000	143,000	8.3	20,700	ND (<140)	ND (<130)	11.8	291,000	ND (<130)	ND (<340)
Isophorone	ND (<640)	ND (<610)	ND (<0.59)	ND (<120)	ND (<110)	ND (<100)	ND (<0.59)	ND (<310)	ND (<100)	ND (<270)
Naphthalene	6,080,000	1,200,000	23.9	75,700	ND (<120)	ND (<120)	1050	4,560,000	ND (<120)	ND (<310)
Nitrobenzene	ND (<890)	ND (<860)	ND (<0.42)	ND (<170)	ND (<150)	ND (<150)	ND (<0.42)	ND (<440)	ND (<150)	ND (<380)
N-Nitroso-di-n-propylamine	ND (<820)	ND (<790)	ND (<0.47)	ND (<150)	ND (<140)	ND (<130)	ND (<0.47)	ND (<400)	ND (<140)	ND (<350)
N-Nitrosodiphenylamine	ND (<530)	ND (<510)	ND (<0.52)	ND (<99)	ND (<88)	ND (<86)	ND (<0.52)	ND (<260)	ND (<87)	ND (<220)
Pentachlorophenol	ND (<1,400)	ND (<1,400)	ND (<0.3)	ND (<270)	ND (<240)	ND (<230)	ND (<0.3)	ND (<700)	ND (<240)	ND (<610)
Phenanthrene	4,090,000	2,080,000	139	179,000	ND (<94)	ND (<92)	302	3,000,000	630	ND (<240)
Phenol	ND (<1,600)	ND (<1,500)	9.0	ND (<300)	ND (<270)	ND (<260)	ND (<0.5)	ND (<770)	ND (<260)	ND (<670)
Pyrene	2,370,000	1,210,000	81.9	108,000	ND (<74)	ND (<72)	31.8	1,180,000	ND (<73)	504 J
Total TIC, Semivolatile	884,400 J	693,800 J	370.4 J	504,300 J	4,900 J	ND	778 J	367,200 J	ND	234,800 J
Total Semivolatiles (target)	26,854,770	11,164,200	656.03	984,820	592	ND	2110.79	19,296,130	2,263	1,968

Notes:

J: Estimated value

ND: Not detected at quoted Method Detection Limit

B: Analyte detected in method blank.

a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)

b: Sample received out of holding time for pH analysis

c: Elevated detection limit due to difficult sample matrix

d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Column Test Data		SS-1 Autoclave Test Data						
	Persulfate	Fenton	Fenton Autoclave				Persulfate Autoclave		
	Soil	Soil	Leachate	Soil	Silica Gel	Carbon	Leachate	Soil	Carbon
General Chemistry (mg/L unless noted)									
Solids, Percent	76.5	79.3		82.0	93.5	93.7		69.6	92.2
Chromium, Hexavalent									
Iron, Ferrous									
Nitrogen, Nitrate ^a									
Nitrogen, Nitrate + Nitrite									
Nitrogen, Nitrite									
Petroleum Hydrocarbons									
Phosphorus, Total									
Sulfate									
Total Organic Carbon									
pH, standard units									
As(III) (ug/L)									
As(V) (ug/L)									
Metals (ug/L or mg/kg)									
Arsenic									
Barium									
Cadmium									
Chromium									
Iron									
Lead									
Manganese									
Mercury									
Selenium									
Silver									
Thallium									

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-2. SS-2 Laboratory Analytical Results

Analyte	SS-2 Baseline Data		SS-2 Slurry Test Data											
			Persulfate 10:1 (SS2-P-10)		Persulfate 20:1 (SS2-P-20)		Persulfate 40:1 (SS2-P-40)		Fenton 10:1 (SS2-F-10)		Fenton 20:1 (SS2-F-20)		Fenton 40:1 (SS2-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Volatiles (ug/L or ug/kg)														
1,1,1-Trichloroethane	ND (<2.8)	ND (<1,100)	ND (<1.4)	ND (<3,100)	ND (<1.4)	ND (<2,600)	ND (<1.4)	ND (<2,500)	ND (<0.28)	ND (<5,700)	ND (<0.28)	ND (<1,000)	ND (<1.4)	ND (<230)
1,1,2,2-Tetrachloroethane	ND (<2.8)	ND (<1,000)	ND (<1.4)	ND (<3,000)	ND (<1.4)	ND (<2,500)	ND (<1.4)	ND (<2,400)	ND (<0.28)	ND (<5,500)	ND (<0.28)	ND (<1,000)	ND (<1.4)	ND (<230)
1,1,2-Trichloroethane	ND (<3.2)	ND (<980)	ND (<1.6)	ND (<2,800)	ND (<1.6)	ND (<2,400)	ND (<1.6)	ND (<2,300)	ND (<0.32)	ND (<5,100)	ND (<0.32)	ND (<940)	ND (<1.6)	ND (<210)
1,1-Dichloroethane	ND (<2.3)	ND (<870)	ND (<1.2)	ND (<2,500)	ND (<1.2)	ND (<2,100)	ND (<1.2)	ND (<2,000)	ND (<0.23)	ND (<4,600)	ND (<0.23)	ND (<840)	ND (<1.2)	ND (<190)
1,1-Dichloroethene	ND (<3.3)	ND (<1,300)	ND (<1.6)	ND (<3,600)	ND (<1.6)	ND (<3,000)	ND (<1.6)	ND (<2,900)	ND (<0.33)	ND (<6,600)	ND (<0.33)	ND (<1,200)	ND (<1.6)	ND (<270)
1,2,4-Trichlorobenzene	ND (<1.6)	ND (<640)	ND (<0.8)	ND (<1,800)	ND (<0.8)	ND (<1,500)	ND (<0.8)	ND (<1,500)	ND (<0.16)	ND (<3,400)	ND (<0.16)	ND (<610)	ND (<0.8)	ND (<140)
1,2-Dibromo-3-chloropropane	ND (<11)	ND (<3,900)	ND (<5.5)	ND (<11,000)	ND (<5.5)	ND (<9,400)	ND (<5.5)	ND (<9,100)	ND (<1.1)	ND (<21,000)	ND (<1.1)	ND (<3,800)	ND (<5.5)	ND (<840)
1,2-Dibromoethane	ND (<5.2)	ND (<1,000)	ND (<2.6)	ND (<3,000)	ND (<2.6)	ND (<2,500)	ND (<2.6)	ND (<2,400)	ND (<0.52)	ND (<5,400)	ND (<0.52)	ND (<990)	ND (<2.6)	ND (<220)
1,2-Dichlorobenzene	ND (<2.0)	ND (<830)	ND (<1)	ND (<2,400)	ND (<1)	ND (<2,000)	ND (<1.0)	ND (<1,900)	ND (<0.20)	ND (<4,400)	ND (<0.2)	ND (<790)	ND (<1.0)	ND (<180)
1,2-Dichloroethane	ND (<2.9)	ND (<990)	ND (<1.5)	ND (<2,800)	ND (<1.5)	ND (<2,400)	ND (<1.5)	ND (<2,300)	ND (<0.29)	ND (<5,200)	ND (<0.29)	ND (<950)	ND (<1.5)	ND (<210)
1,2-Dichloropropane	ND (<2.0)	ND (<1,000)	ND (<1.0)	ND (<2,900)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,400)	ND (<0.20)	ND (<5,300)	ND (<0.2)	ND (<970)	ND (<1)	ND (<220)
1,3-Dichlorobenzene	ND (<3.2)	ND (<890)	ND (<1.6)	ND (<2,600)	ND (<1.6)	ND (<2,100)	ND (<1.6)	ND (<2,100)	ND (<0.32)	ND (<4,700)	ND (<0.32)	ND (<850)	ND (<1.6)	ND (<190)
1,4-Dichlorobenzene	ND (<2.4)	ND (<840)	ND (<1.2)	ND (<2,400)	ND (<1.2)	ND (<2,000)	ND (<1.2)	ND (<2,000)	ND (<0.24)	ND (<4,400)	ND (<0.24)	ND (<800)	ND (<1.2)	ND (<180)
2-Butanone (MEK)	ND (<26)	ND (<5,000)	29.4 J	ND (<14,000)	ND (<13)	ND (<12,000)	ND (<13)	ND (<12,000)	26.3	ND (<26,000)	42.8	ND (<4,800)	ND (<13)	ND (<1,100)
2-Hexanone	ND (<13)	ND (<2,500)	ND (<6.3)	ND (<7,100)	ND (<6.3)	ND (<6,000)	ND (<6.3)	ND (<5,800)	ND (<1.3)	ND (<13,000)	ND (<1.3)	ND (<2,400)	ND (<6.3)	ND (<530)
4-Methyl-2-pentanone(MIBK)	ND (<11)	ND (<3,600)	ND (<5.3)	ND (<10,000)	ND (<5.3)	ND (<8,700)	ND (<5.3)	ND (<8,500)	ND (<1.1)	ND (<19,000)	ND (<1.1)	ND (<3,500)	ND (<5.3)	ND (<780)
Acetone	ND (<24)	ND (<5,200)	485	ND (<15,000)	ND (<12)	ND (<13,000)	ND (<12)	ND (<12,000)	1,600	ND (<27,000)	2,100	ND (<5,000)	905	ND (<1100)
Benzene	1,670	20,000	34.9	4,700 J	33.4	3,990 J	7.0	5,530	13.7	ND (<4,600)	11.7	2,180	9.3	2,430
Bromodichloromethane	ND (<1.7)	ND (<830)	ND (<0.87)	ND (<2,400)	ND (<0.87)	ND (<2,000)	ND (<0.87)	ND (<1,900)	ND (<0.17)	ND (<4,400)	ND (<0.17)	ND (<800)	ND (<0.87)	ND (<180)
Bromoform	ND (<5.4)	ND (<790)	ND (<2.7)	ND (<2,300)	ND (<2.7)	ND (<1,900)	ND (<2.7)	ND (<1,800)	ND (<0.54)	ND (<4,200)	ND (<0.54)	ND (<760)	ND (<2.7)	ND (<170)
Bromomethane	ND (<2.2)	ND (<670)	ND (<1.1)	ND (<1,900)	ND (<1.1)	ND (<1,600)	ND (<1.1)	ND (<1,600)	ND (<0.22)	ND (<3,500)	ND (<0.22)	ND (<640)	ND (<1.1)	ND (<140)
Carbon disulfide	ND (<2.1)	ND (<1,000)	ND (<1.0)	ND (<2,900)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,300)	2.1	ND (<5,300)	0.94	ND (<960)	ND (<1.0)	ND (<220)
Carbon tetrachloride	ND (<2.9)	ND (<1,700)	ND (<1.5)	ND (<5,000)	ND (<1.5)	ND (<4,200)	ND (<1.5)	ND (<4,000)	ND (<0.29)	ND (<9,100)	ND (<0.29)	ND (<1,700)	ND (<1.5)	ND (<370)
Chlorobenzene	ND (<2.2)	ND (<790)	ND (<1.1)	ND (<2,300)	ND (<1.1)	ND (<1,900)	ND (<1.1)	ND (<1,800)	ND (<0.22)	ND (<4,200)	ND (<0.22)	ND (<760)	ND (<1.1)	ND (<170)
Chloroethane	ND (<5.6)	ND (<3,200)	ND (<2.8)	ND (<9,100)	ND (<2.8)	ND (<7,600)	ND (<2.8)	ND (<7,400)	ND (<0.56)	ND (<17,000)	ND (<0.56)	ND (<3,000)	ND (<2.8)	ND (<680)
Chloroform	ND (<2.2)	ND (<1,100)	ND (<1.1)	ND (<3,000)	ND (<1.1)	ND (<2,600)	5.4	ND (<2,500)	ND (<0.22)	ND (<5,600)	ND (<0.22)	ND (<1,000)	ND (<1.1)	ND (<230)
Chloromethane	ND (<3.5)	ND (<840)	ND (<1.7)	ND (<2,400)	ND (<1.7)	ND (<2,000)	ND (<1.7)	ND (<2,000)	ND (<0.35)	ND (<4,400)	ND (<0.35)	ND (<810)	ND (<1.7)	ND (<180)
cis-1,2-Dichloroethene	ND (<1.8)	ND (<1,200)	ND (<0.89)	ND (<3,500)	ND (<0.89)	ND (<2,900)	ND (<0.89)	ND (<2,900)	ND (<0.18)	ND (<6,400)	ND (<0.18)	ND (<1,200)	ND (<0.89)	ND (<260)
cis-1,3-Dichloropropene	ND (<1.5)	ND (<760)	ND (<0.74)	ND (<2,200)	ND (<0.74)	ND (<1,800)	ND (<0.74)	ND (<1,800)	ND (<0.15)	ND (<4,000)	ND (<0.15)	ND (<720)	ND (<0.74)	ND (<160)
Cyclohexane	ND (<5)	ND (<2,300)	ND (<2.5)	ND (<6,700)	ND (<2.5)	ND (<5,600)	ND (<2.5)	ND (<5,400)	ND (<0.50)	ND (<12,000)	ND (<0.5)	ND (<2,200)	ND (<2.5)	ND (<500)
Dibromochloromethane	ND (<1.9)	ND (<1,000)	ND (<0.94)	ND (<2,900)	ND (<0.94)	ND (<2,400)	ND (<0.94)	ND (<2,300)	ND (<0.19)	ND (<5,300)	ND (<0.19)	ND (<960)	ND (<0.94)	ND (<220)
Dichlorodifluoromethane	ND (<7.5)	ND (<1,400)	ND (<3.8)	ND (<4,200)	ND (<3.8)	ND (<3,500)	ND (<3.8)	ND (<3,400)	ND (<0.75)	ND (<7,600)	ND (<0.75)	ND (<1,400)	ND (<3.8)	ND (<310)
Ethylbenzene	718	153,000	4.4 J	82,600	34.9	74,700	ND (<1.0)	68,800	25.3	17,800	5.0	2,850	3.3 J	2,120
Freon 113	ND (<6.9)	ND (<1,600)	ND (<3.4)	ND (<4,500)	ND (<3.4)	ND (<3,800)	ND (<3.4)	ND (<3,600)	ND (<0.69)	ND (<8,200)	ND (<0.69)	ND (<1,500)	ND (<3.4)	ND (<340)
Isopropylbenzene	39.5	32,500	ND (<1.0)	16,500 J	3.0 J	16,900 J	ND (<1.0)	16,000	4.5	5,360 J	0.91	ND (<810)	ND (<1.0)	209 J
m,p-Xylene	729	196,000	ND (<2.1)	103,000	32.0	93,800	ND (<2.1)	85,900	48.2	27,600	9.1	3,640	4.4 J	2,450
Methyl Acetate	ND (<21)	ND (<2,600)	ND (<10)	ND (<7,400)	ND (<10)	ND (<6,200)	ND (<10)	ND (<6,000)	ND (<2.1)	ND (<14,000)	ND (<2.1)	6,420 J	ND (<10)	14,000
Methyl Tert Butyl Ether	ND (<3.1)	ND (<1,000)	ND (<1.5)	ND (<2,900)	ND (<1.5)	ND (<2,500)	ND (<1.5)	ND (<2,400)	ND (<0.31)	ND (<5,400)	ND (<0.31)	ND (<980)	ND (<1.5)	ND (<220)
Methylcyclohexane	ND (<1.8)	ND (<1,200)	ND (<0.91)	ND (<3,400)	ND (<0.91)	ND (<2,800)	ND (<0.91)	ND (<2,700)	ND (<0.18)	ND (<6,200)	ND (<0.18)	ND (<1,100)	ND (<0.91)	ND (<250)
Methylene chloride	ND (<2.7)	ND (<1,300)	ND (<1.3)	ND (<3,600)	ND (<1.3)	ND (<3,000)	ND (<1.3)	ND (<2,900)	ND (<0.27)	ND (<6,600)	ND (<0.27)	ND (<1,200)	ND (<1.3)	ND (<270)
o-Xylene	442	97,300	2.4 J	50,600	22.3	44,700	ND (<1.5)	41,300	31.1	12,000	5.8	1,320 J	2.1 J	563
Styrene	ND (<1.6)	ND (<600)	ND (<0.79)	ND (<1,700)	ND (<0.79)	ND (<1,400)	ND (<0.79)	ND (<1,400)	ND (<0.16)	ND (<3,100)	ND (<0.16)	ND (<570)	ND (<0.79)	187 J
Tetrachloroethene	ND (<2.8)	ND (<1,500)	ND (<1.4)	ND (<4,300)	ND (<1.4)	ND (<3,600)	ND (<1.4)	ND (<3,500)	ND (<0.28)	ND (<7,900)	ND (<0.28)	ND (<1,400)	ND (<1.4)	ND (<320)
Toluene	452	81,800	14.5	30,500	41.5	25,600	2.7 J	23,100	19.6	5,340 J	8.6	3,110	7.6	3,480
trans-1,2-Dichloroethene	ND (<4.2)	ND (<1,200)	ND (<2.1)	ND (<3,600)	ND (<2.1)	ND (<3,000)	ND (<2.1)	ND (<2,900)	ND (<0.42)	ND (<6,600)	ND (<0.42)	ND (<1,200)	ND (<2.1)	ND (<270)
trans-1,3-Dichloropropene	ND (<2)	ND (<720)	ND (<1.0)	ND (<2,100)	ND (<1)	ND (<1,700)	ND (<1.0)	ND (<1,700)	ND (<0.2)	ND (<3,800)	ND (<0.20)	ND (<680)	ND (<1.0)	ND (<150)
Trichloroethene	ND (<2.9)	ND (<950)	ND (<1.4)	ND (<2,700)	ND (<1.4)	ND (<2,300)	ND (<1.4)	ND (<2,200)	ND (<0.29)	ND (<5,000)	ND (<0.29)	ND (<910)	ND (<1.4)	ND (<200)
Trichlorofluoromethane	ND (<2.5)	ND (<1,300)	ND (<1.3)	ND (<3,800)	ND (<1.3)	ND (<3,200)	ND (<1.3)	ND (<3,100)	ND (<0.25)	ND (<7,000)	ND (<0.25)	ND (<1,300)	ND (<1.3)	ND (<290)
Vinyl chloride	ND (<2.9)	ND (<1,200)	ND (<1.4)	ND (<3,400)	ND (<1.4)	ND (<2,800)	ND (<1.4)	ND (<2,700)	ND (<0.29)	ND (<6,200)	ND (<0.29)	ND (<1,100)	ND (<1.4)	ND (<250)
Xylene (total)	1,170	293,000	4.5 J	154,000	54.3	138,000	ND (<1.5)	127,000	79.3	39,500	14.9	4,970	6.5	3,010
Total TIC, Volatile	17,317 J	4,246,000 J	310 J	6,558,000	4,279 J	8,577,000 J	25 J	8,548,000 J	1,969 J	3,041,000 J	1,230 J	625,000 J	304 J	136,800 J
Total Volatiles (Target)	5,221	873,600	575	441,900	221	397,690	15	367,630	1,850	107,600	2,200	24,490	938	28,449

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-2. SS-2 Laboratory Analytical Results

Analyte	SS-2 Baseline Data		SS-2 Slurry Test Data											
			Persulfate 10:1 (SS2-P-10)		Persulfate 20:1 (SS2-P-20)		Persulfate 40:1 (SS2-P-40)		Fenton 10:1 (SS2-F-10)		Fenton 20:1 (SS2-F-20)		Fenton 40:1 (SS2-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Semivolatiles (ug/L or ug/kg)														
1,1'-Biphenyl	48.8	614,000	25.7	276,000	21.5	306,000	ND (<6.5)	366,000	94.7	345,000	142	145,000	26.6	46,400 J
2,4,5-Trichlorophenol	ND (<2.2)	ND (<930)	ND (<1.9)	ND (<760)	ND (<1.9)	ND (<340)	ND (<39)	ND (<340)	ND (<1.9)	ND (<430)	ND (<1.9)	ND (<400)	ND (<1.9)	ND (<360)
2,4,6-Trichlorophenol	ND (<1.4)	ND (<520)	ND (<1.3)	ND (<430)	ND (<1.3)	ND (<190)	ND (<25)	ND (<190)	ND (<1.3)	ND (<240)	ND (<1.3)	ND (<220)	ND (<1.3)	ND (<200)
2,4-Dichlorophenol	ND (<1.8)	ND (<1,000)	ND (<1.6)	ND (<850)	ND (<1.6)	ND (<380)	ND (<31)	ND (<370)	ND (<1.6)	ND (<480)	ND (<1.6)	ND (<440)	ND (<1.6)	ND (<410)
2,4-Dimethylphenol	396 J	41,100	ND (<1.6)	ND (<1300)	ND (<1.6)	ND (<580)	ND (<33)	ND (<570)	37.3	ND (<730)	26.5	ND (<680)	8.7	781 J
2,4-Dinitrophenol	ND (<1)	ND (<940)	ND (<0.89)	ND (<770)	ND (<0.89)	ND (<350)	ND (<18)	ND (<340)	ND (<0.89)	ND (<440)	ND (<0.89)	ND (<400)	ND (<0.89)	ND (<370)
2,4-Dinitrotoluene	ND (<0.98)	ND (<720)	ND (<0.86)	ND (<590)	ND (<0.86)	ND (<260)	ND (<17)	ND (<260)	ND (<0.86)	ND (<330)	ND (<0.86)	ND (<310)	ND (<0.86)	ND (<280)
2,6-Dinitrotoluene	ND (<0.64)	ND (<710)	ND (<0.56)	ND (<580)	ND (<0.56)	ND (<260)	ND (<11)	ND (<260)	ND (<0.56)	ND (<330)	ND (<0.56)	ND (<300)	ND (<0.56)	ND (<280)
2-Chloronaphthalene	ND (<1.1)	ND (<870)	ND (<0.98)	ND (<710)	ND (<0.98)	ND (<320)	ND (<20)	ND (<310)	ND (<0.98)	ND (<400)	ND (<0.98)	ND (<370)	ND (<0.98)	ND (<340)
2-Chlorophenol	ND (<1.1)	ND (<530)	ND (<0.95)	ND (<440)	ND (<0.95)	ND (<190)	ND (<19)	ND (<190)	ND (<0.95)	ND (<250)	ND (<0.95)	ND (<230)	ND (<0.95)	ND (<210)
2-Methylnaphthalene	319	3,070,000	113	1,300,000	30	1,050,000	ND (<8.2)	1,720,000	416	1,110,000	345 B	266,000	50.7	61,400
2-Methylphenol	60.8	5,590	ND (<1.4)	ND (<500)	ND (<1.4)	ND (<220)	ND (<27)	ND (<220)	ND (<1.4)	ND (<280)	19.8	ND (<260)	9.4	ND (<240)
2-Nitroaniline	ND (<0.75)	ND (<390)	ND (<0.66)	ND (<320)	ND (<0.66)	ND (<140)	ND (<13)	ND (<140)	ND (<0.66)	ND (<180)	ND (<0.66)	ND (<170)	ND (<0.66)	ND (<150)
2-Nitrophenol	ND (<2.1)	ND (<770)	ND (<1.8)	ND (<630)	ND (<1.8)	ND (<280)	ND (<36)	ND (<280)	ND (<1.8)	ND (<350)	ND (<1.8)	ND (<330)	ND (<1.8)	ND (<300)
3&4-Methylphenol	210 J	ND (<880)	ND (<1.3)	ND (<730)	ND (<1.3)	ND (<330)	ND (<25)	ND (<320)	24.3	ND (<410)	48.2	ND (<380)	25.1	ND (<350)
3,3'-Dichlorobenzidine	ND (<1.4)	ND (<590)	ND (<1.2)	ND (<490)	ND (<1.2)	ND (<220)	ND (<24)	ND (<210)	ND (<1.2)	ND (<270)	ND (<1.2)	ND (<250)	ND (<1.2)	ND (<230)
3-Nitroaniline	ND (<1.4)	ND (<480)	ND (<1.3)	ND (<390)	ND (<1.3)	ND (<180)	ND (<25)	ND (<170)	ND (<1.3)	ND (<220)	ND (<1.3)	ND (<200)	ND (<1.3)	ND (<190)
4,6-Dinitro-o-cresol	ND (<0.82)	ND (<540)	ND (<0.72)	ND (<440)	ND (<0.72)	ND (<200)	ND (<14)	ND (<200)	ND (<0.72)	ND (<250)	ND (<0.72)	ND (<230)	ND (<0.72)	ND (<210)
4-Bromophenyl phenyl ether	ND (<0.34)	ND (<310)	ND (<0.3)	ND (<260)	ND (<0.3)	ND (<120)	ND (<6.0)	ND (<110)	ND (<0.30)	ND (<150)	ND (<0.3)	ND (<130)	ND (<0.3)	ND (<120)
4-Chloro-3-methyl phenol	ND (<1.3)	ND (<790)	ND (<1.2)	ND (<650)	ND (<1.2)	ND (<290)	ND (<24)	ND (<280)	ND (<1.2)	ND (<360)	ND (<1.2)	ND (<340)	ND (<1.2)	ND (<310)
4-Chloroaniline	ND (<0.45)	ND (<380)	ND (<0.4)	ND (<320)	ND (<0.40)	ND (<140)	ND (<7.9)	ND (<140)	ND (<0.40)	ND (<180)	ND (<0.4)	ND (<160)	ND (<0.4)	ND (<150)
4-Chlorophenyl phenyl ether	ND (<0.49)	ND (<290)	ND (<0.43)	ND (<240)	ND (<0.43)	ND (<110)	ND (<8.6)	ND (<110)	ND (<0.43)	ND (<130)	ND (<0.43)	ND (<120)	ND (<0.43)	ND (<110)
4-Nitroaniline	ND (<0.82)	ND (<430)	ND (<0.72)	ND (<350)	ND (<0.72)	ND (<160)	ND (<14)	ND (<150)	ND (<0.72)	ND (<200)	ND (<0.72)	ND (<180)	ND (<0.72)	ND (<170)
4-Nitrophenol	ND (<0.96)	ND (<840)	ND (<0.84)	ND (<690)	ND (<0.84)	ND (<310)	ND (<17)	ND (<300)	ND (<0.84)	ND (<390)	ND (<0.84)	ND (<360)	ND (<0.84)	ND (<330)
Acenaphthene	112 J	2,200,000	7.8	780,000	30.8	656,000	ND (<7.0)	935,000	216	898,000	279	301,000	37.1	82,700
Acenaphthylene	15	111,000	3.5	38,700	ND (<0.38)	39,100	ND (<7.6)	44,500	14.9	48,100 J	12.2	20,100 J	ND (<0.38)	20,200
Acetophenone	ND (<0.42)	ND (<390)	28.1	ND (<320)	19.8	ND (<140)	ND (<7.5)	ND (<140)	46.6	ND (<180)	45.5	ND (<170)	25	ND (<150)
Anthracene	12	2,320,000	ND (<0.4)	444,000	ND (<0.40)	418,000	ND (<8.0)	379,000	10.8	602,000	11.9	356,000	7.8	112,000
Atrazine	ND (<0.19)	ND (<530)	ND (<0.16)	ND (<440)	ND (<0.16)	ND (<200)	ND (<3.3)	ND (<190)	ND (<0.16)	ND (<250)	ND (<0.16)	ND (<230)	ND (<0.16)	ND (<210)
Benzaldehyde	ND (<0.3)	ND (<680)	ND (<0.27)	ND (<560)	ND (<0.27)	ND (<250)	ND (<5.3)	ND (<250)	ND (<0.27)	ND (<310)	ND (<0.27)	ND (<290)	ND (<0.27)	ND (<270)
Benzo(a)anthracene	1.5 J	457,000	1.3 J	218,000	ND (<0.36)	246,000	ND (<7.1)	285,000	ND (<0.36)	425,000	ND (<0.36)	223,000	2.4	136,000
Benzo(a)pyrene	1 J	273,000	0.8 J	133,000	ND (<0.37)	132,000	ND (<7.3)	134,000	ND (<0.37)	251,000	ND (<0.37)	122,000	1 J	68,100
Benzo(b)fluoranthene	ND (<0.67)	229,000	ND (<0.59)	119,000	ND (<0.59)	147,000	ND (<12)	177,000	ND (<0.59)	299,000	ND (<0.59)	113,000	1.2 J	109,000
Benzo(g,h,i)perylene	0.77 J	161,000	ND (<0.42)	67,200	ND (<0.42)	73,800	ND (<8.4)	90,600	ND (<0.42)	127,000	ND (<0.42)	61,400	0.69 J	39,400 J
Benzo(k)fluoranthene	0.88 J	202,000	0.71 J	106,000	ND (<0.42)	112,000	ND (<8.4)	139,000	ND (<0.42)	158,000	ND (<0.42)	129,000	1.5 J	58,800
bis(2-Chloroethoxy)methane	ND (<0.74)	ND (<400)	ND (<0.65)	ND (<330)	ND (<0.65)	ND (<150)	ND (<13)	ND (<140)	ND (<0.65)	ND (<180)	ND (<0.65)	ND (<170)	ND (<0.65)	ND (<160)
bis(2-Chloroethyl)ether	ND (<0.6)	ND (<310)	ND (<0.53)	ND (<250)	ND (<0.53)	ND (<110)	ND (<11)	ND (<110)	ND (<0.53)	ND (<140)	ND (<0.53)	ND (<130)	ND (<0.53)	ND (<120)
bis(2-Chloroisopropyl)ether	ND (<0.84)	ND (<460)	ND (<0.74)	ND (<380)	ND (<0.74)	ND (<170)	ND (<15)	ND (<170)	ND (<0.74)	ND (<210)	ND (<0.74)	ND (<200)	ND (<0.74)	ND (<180)
bis(2-Ethylhexyl)phthalate	ND (<0.75)	ND (<790)	ND (<0.66)	ND (<650)	ND (<0.66)	1,390	ND (<13)	1,560	ND (<0.66)	ND (<370)	ND (<0.66)	ND (<340)	ND (<0.66)	ND (<310)
Butyl benzyl phthalate	ND (<0.67)	ND (<470)	ND (<0.59)	ND (<380)	ND (<0.59)	ND (<170)	ND (<12)	ND (<170)	ND (<0.59)	ND (<220)	ND (<0.59)	ND (<200)	ND (<0.59)	ND (<180)
Caprolactam	ND (<0.36)	ND (<600)	ND (<0.32)	ND (<490)	ND (<0.32)	ND (<220)	ND (<6.3)	ND (<220)	ND (<0.32)	ND (<280)	ND (<0.32)	ND (<250)	ND (<0.32)	ND (<230)
Carbazole	157 J	719,000	3.1	47,600	0.57 J	26,900	ND (<7.3)	21,400	92.4	143,000	63.8	80,100	23.5	20,400
Chrysene	1.5 J	465,000	1.3 J	195,000	ND (<0.25)	229,000	ND (<5.0)	273,000	ND (<0.25)	410,000	ND (<0.25)	235,000	2.8	166,000
Dibenzo(a,h)anthracene	ND (<0.62)	38,200	ND (<0.54)	23,100	ND (<0.54)	23,100	ND (<11)	30,000	ND (<0.54)	34,600 J	ND (<0.54)	21,000 J	ND (<0.54)	18,000 J
Dibenzofuran	82.9	1,570,000	58.6	616,000	35.6	557,000	ND (<6.9)	874,000	155 J	762,000	201	330,000	34.9	93,700
Diethyl phthalate	ND (<0.44)	ND (<260)	ND (<0.39)	ND (<220)	ND (<0.39)	ND (<97)	ND (<7.8)	ND (<96)	ND (<0.39)	ND (<120)	ND (<0.39)	ND (<110)	ND (<0.39)	ND (<100)
Dimethyl phthalate	ND (<0.37)	ND (<270)	ND (<0.33)	ND (<220)	ND (<0.33)	ND (<98)	ND (<6.6)	ND (<96)	ND (<0.33)	ND (<120)	ND (<0.33)	ND (<110)	ND (<0.33)	ND (<100)
Di-n-butyl phthalate	ND (<0.67)	ND (<390)	ND (<0.59)	ND (<320)	ND (<0.59)	ND (<140)	ND (<12)	ND (<140)	1.3 J	ND (<180)	ND (<0.59)	ND (<170)	ND (<0.59)	ND (<150)
Di-n-octyl phthalate	ND (<0.65)	ND (<530)	ND (<0.57)	ND (<440)	ND (<0.57)	ND (<190)	ND (<11)	ND (<190)	ND (<0.57)	ND (<240)	ND (<0.57)	ND (<230)	ND (<0.57)	ND (<210)
Fluoranthene	11	2,010,000	4.7	955,000	ND (<0.25)	1,160,000	ND (<5.0)	1,420,000	2.8	1,500,000	4.4	837,000	15.6	487,000
Fluorene	63.1	1,860,000	20.7	629,000	3.2	563,000	ND (<9.0)	716,000	190	1,090,000	280	540,000	76.5	210,000
Hexachlorobenzene	ND (<0.61)</													

Table 4-2. SS-2 Laboratory Analytical Results

Analyte	SS-2 Baseline Data		SS-2 Slurry Test Data											
	Groundwater	Soil	Persulfate 10:1 (SS2-P-10)		Persulfate 20:1 (SS2-P-20)		Persulfate 40:1 (SS2-P-40)		Fenton 10:1 (SS2-F-10)		Fenton 20:1 (SS2-F-20)		Fenton 40:1 (SS2-F-40)	
			Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry														
(mg/L unless noted)														
Solids, Percent		80.8		64.6		72.6		74.1		68.5		72.8		77.8
Chromium, Hexavalent	ND (<0.010)				0.034						0.069			
Iron, Ferrous	36.1				0.98						249			
Nitrogen, Nitrate ^a	ND (<0.11)				4.5						2.0			
Nitrogen, Nitrate + Nitrite	ND (<0.10)				4.6						2.0			
Nitrogen, Nitrite	ND (<0.010)				0.12						ND (<0.010)			
Petroleum Hydrocarbons	2.5	7,270		5,440	ND (<0.62)	1,550		3,360		4,140	ND (<0.51)	1,990		657
Phosphorus, Total	0.11				4.8						ND (<0.050)			
Sulfate	414				50,600						4,520			
Total Organic Carbon	20.7	297,000	516	248,000	546	321,000	845	208,000	1,340	251,000	1,790	228,000	1,430	364,000
pH, standard units	6.34 b		10.21		13.06		13.42		2.31		2.21		2.31	
As(III) (ug/L)	110				ND (<0.56)						6.53			
As(V) (ug/L)	15.9				729						1,090			
Metals (ug/L or mg/kg)														
Arsenic	342	9.9	480	7.7	767	4.2	834	8.9	583	6.1	928	9.2	262	12.6
Barium	236	92.2	ND (<400) c	62.8	ND (<400) c	43.1	ND (<1,000) c	38.9	265	53.9	317	54.6	290	85.1
Cadmium	ND (<4.0)	ND (<0.63)	ND (<8.0) c	ND (<0.74)	ND (<8.0) c	ND (<0.72)	ND (<20) c	ND (<0.70)	40.4	ND (<0.72)	36.0	ND (<0.72)	36.3	ND (<0.66)
Chromium	ND (<10)	9.0	137	5.9	192	5.2	310	3.2	363	5.4	463	87.9	636	101
Iron	41,800	10,700	707	8,940	ND (<200) c	9,010	ND (<500) c	7,450	1,100,000	6,900	1,550,000	5,910	1,540,000	8,490
Lead	3.9	116	6.2	132	395	64.6	4,280	42.5	3,490	65.7	2,900	80.4	3,060	101
Manganese	3,650		ND (<30) c	149	ND (<30) c	88.5	ND (<75) c	55.0	7,300	40.6	9,070	46.5	8,130	56.5
Mercury	ND (<0.20)	2.1	ND (<0.40) c	1.7	ND (<0.40) c	0.83	2.4	1.7	ND (<0.20)	0.23	ND (<0.20)	1.8	ND (<0.20) c	0.61
Selenium	ND (<10)	ND (<2.5)	134	ND (<3.0)	164	ND (<2.9)	211	ND (<2.8)	74.3	ND (<2.9)	93.1	ND (<2.9)	137	ND (<2.6)
Silver	ND (<10)	ND (<1.3)	ND (<20) c	ND (<1.5)	ND (<20) c	ND (<1.4)	ND (<50) c	ND (<1.4)	ND (<10)	ND (<1.4)	ND (<10)	ND (<1.4)	ND (<10)	ND (<1.3)
Thallium	ND (<10)	ND (<1.3)	ND (<20) c	ND (<1.5)	ND (<20) c	ND (<1.4)	ND (<50) c	ND (<1.4)	ND (<20) c	ND (<1.4)	ND (<50) c	ND (<1.4)	ND (<50) c	ND (<1.3)

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-3. P-1 Laboratory Analytical Results

Analyte	P-1 Baseline Data		P-1 Slurry Test Data											
			Persulfate 10:1 (P1-P-10)		Persulfate 20:1 (P1-P-20)		Persulfate 40:1 (P1-P-40)		Fenton 10:1 (P1-F-10)		Fenton 20:1 (P1-F-20)		Fenton 40:1 (P1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Volatiles (ug/L or ug/kg)														
1,1,1-Trichloroethane	ND (<5.5)	ND (<180)	ND (<6.9)	ND (<1,300)	ND (<14)	ND (<1,200)	ND (<14)	ND (<1,400)	ND (<0.28)	ND (<3.7)	ND (<0.28)	ND (<2.7)	ND (<0.28)	ND (<1.8)
1,1,2,2-Tetrachloroethane	ND (<5.5)	ND (<180)	ND (<6.9)	ND (<1,300)	ND (<14)	ND (<1,200)	ND (<14)	ND (<1,300)	ND (<0.28)	ND (<3.6)	ND (<0.28)	ND (<2.6)	ND (<0.28)	ND (<1.7)
1,1,2-Trichloroethane	ND (<6.3)	ND (<160)	ND (<7.9)	ND (<1,200)	ND (<16)	ND (<1,100)	ND (<16)	ND (<1,200)	ND (<0.32)	ND (<3.4)	ND (<0.32)	ND (<2.4)	ND (<0.32)	ND (<1.6)
1,1-Dichloroethane	ND (<4.7)	ND (<150)	ND (<5.8)	ND (<1,100)	ND (<12)	ND (<980)	ND (<12)	ND (<1,100)	ND (<0.23)	ND (<3.0)	ND (<0.23)	ND (<2.2)	ND (<0.23)	ND (<1.4)
1,1-Dichloroethene	ND (<6.5)	ND (<210)	ND (<8.1)	ND (<1,600)	ND (<16)	ND (<1,400)	ND (<16)	ND (<1,600)	ND (<0.33)	ND (<4.3)	ND (<0.33)	ND (<3.1)	ND (<0.33)	ND (<2.0)
1,2,4-Trichlorobenzene	ND (<3.2)	ND (<110)	ND (<4)	ND (<800)	ND (<8.0)	ND (<720)	ND (<8)	ND (<810)	ND (<0.16)	ND (<2.2)	ND (<0.16)	ND (<1.6)	ND (<0.16)	ND (<1.0)
1,2-Dibromo-3-chloropropane	ND (<22)	ND (<660)	ND (<27)	ND (<4,900)	ND (<55)	ND (<4,400)	ND (<55)	ND (<4,900)	ND (<1.1)	ND (<13)	ND (<1.1)	ND (<9.7)	ND (<1.1)	ND (<6.4)
1,2-Dibromoethane	ND (<10)	ND (<170)	ND (<13)	ND (<1,300)	ND (<26)	ND (<1,200)	ND (<26)	ND (<1,300)	ND (<0.52)	ND (<3.5)	ND (<0.52)	ND (<2.5)	ND (<0.52)	ND (<1.7)
1,2-Dichlorobenzene	ND (<4.1)	ND (<140)	ND (<5.1)	ND (<1,000)	ND (<10)	ND (<930)	ND (<10)	ND (<1,000)	ND (<0.2)	ND (<2.8)	ND (<0.20)	ND (<2)	ND (<0.20)	ND (<1.4)
1,2-Dichloroethane	ND (<5.9)	ND (<170)	ND (<7.3)	ND (<1,200)	ND (<15)	ND (<1,100)	ND (<15)	ND (<1,200)	ND (<0.29)	ND (<3.4)	ND (<0.29)	ND (<2.4)	ND (<0.29)	ND (<1.6)
1,2-Dichloropropane	ND (<4.0)	ND (<170)	ND (<5)	ND (<1,300)	ND (<10)	ND (<1,100)	ND (<10)	ND (<1,300)	ND (<0.20)	ND (<3.5)	ND (<0.20)	ND (<2.5)	ND (<0.20)	ND (<1.6)
1,3-Dichlorobenzene	ND (<6.3)	ND (<150)	ND (<7.9)	ND (<1,100)	ND (<16)	ND (<1,000)	ND (<16)	ND (<1,100)	ND (<0.32)	ND (<3.1)	ND (<0.32)	ND (<2.2)	ND (<0.32)	ND (<1.4)
1,4-Dichlorobenzene	ND (<4.8)	ND (<140)	ND (<6)	ND (<1,000)	ND (<12)	ND (<940)	ND (<12)	ND (<1,100)	ND (<0.24)	ND (<2.9)	ND (<0.24)	ND (<2.1)	ND (<0.24)	ND (<1.4)
2-Butanone (MEK)	ND (<52)	ND (<840)	ND (<65)	ND (<6,200)	ND (<130)	ND (<5,600)	ND (<130)	ND (<6,300)	44	237	50.9	147	172	192
2-Hexanone	ND (<25)	ND (<420)	ND (<32)	ND (<3,100)	ND (<63)	ND (<2,800)	ND (<63)	ND (<3,100)	ND (<1.3)	ND (<8.5)	ND (<1.3)	ND (<6.1)	ND (<1.3)	ND (<4)
4-Methyl-2-pentanone (MIBK)	ND (<21)	ND (<610)	ND (<27)	ND (<4,500)	ND (<53)	ND (<4,100)	ND (<53)	ND (<4,600)	ND (<1.1)	ND (<12)	ND (<1.1)	ND (<9)	ND (<1.1)	ND (<5.9)
Acetone	ND (<48)	ND (<880)	554	ND (<6,500)	806	ND (<5,800)	757	ND (<6,600)	597	1,590	528	982	2,340	2,100
Benzene	1,500	9,210	325	2,310	277	2,090	239	2,360	5.7	78	1.3	24.9	3.4	9.4
Bromodichloromethane	ND (<3.5)	ND (<140)	ND (<4.4)	ND (<1,000)	ND (<8.7)	ND (<930)	ND (<8.7)	ND (<1,000)	ND (<0.17)	ND (<2.9)	ND (<0.17)	ND (<2.1)	ND (<0.17)	ND (<1.4)
Bromoform	ND (<11)	ND (<130)	ND (<13)	ND (<990)	ND (<27)	ND (<890)	ND (<27)	ND (<1,000)	ND (<0.54)	ND (<2.7)	ND (<0.54)	ND (<2.0)	ND (<0.54)	ND (<1.3)
Bromomethane	ND (<4.5)	ND (<110)	ND (<5.6)	ND (<840)	ND (<11)	ND (<750)	ND (<11)	ND (<850)	ND (<0.22)	ND (<2.3)	ND (<0.22)	ND (<1.7)	ND (<0.22)	ND (<1.1)
Carbon disulfide	ND (<4.1)	ND (<170)	17.2 J	ND (<1,300)	51.4 J	ND (<1,100)	52.6 J	ND (<1,300)	28.9	788	5.8	269	14.9	120
Carbon tetrachloride	ND (<5.8)	ND (<290)	ND (<7.3)	ND (<2,200)	ND (<15)	ND (<1,900)	ND (<15)	ND (<2,200)	ND (<0.29)	ND (<5.9)	ND (<0.29)	ND (<4.3)	ND (<0.29)	ND (<2.8)
Chlorobenzene	ND (<4.5)	ND (<130)	ND (<5.6)	ND (<990)	ND (<11)	ND (<880)	ND (<11)	ND (<1,000)	ND (<0.22)	ND (<2.7)	ND (<0.22)	ND (<2.0)	ND (<0.22)	ND (<1.3)
Chloroethane	ND (<11)	ND (<530)	ND (<14)	ND (<4,000)	ND (<28)	ND (<3,600)	ND (<28)	ND (<4,000)	ND (<0.56)	ND (<11)	ND (<0.56)	ND (<7.8)	ND (<0.56)	ND (<5.2)
Chloroform	ND (<4.3)	ND (<180)	7.1 J	ND (<1,300)	ND (<11)	ND (<1,200)	ND (<11)	ND (<1,300)	ND (<0.22)	ND (<3.6)	ND (<0.22)	ND (<2.6)	ND (<0.22)	ND (<1.7)
Chloromethane	ND (<7)	ND (<140)	ND (<8.7)	ND (<1,000)	ND (<17)	ND (<940)	ND (<17)	ND (<1,100)	2.3	ND (<2.9)	ND (<0.35)	ND (<2.1)	1.0	ND (<1.4)
cis-1,2-Dichloroethene	ND (<3.6)	ND (<210)	ND (<4.5)	ND (<1,500)	ND (<8.9)	ND (<1,400)	ND (<8.9)	ND (<1,500)	ND (<0.18)	ND (<4.2)	ND (<0.18)	ND (<3)	ND (<0.18)	ND (<2.0)
cis-1,3-Dichloropropene	ND (<3)	ND (<130)	ND (<3.7)	ND (<940)	ND (<7.4)	ND (<850)	ND (<7.4)	ND (<950)	ND (<0.15)	ND (<2.6)	ND (<0.15)	ND (<1.9)	ND (<0.15)	ND (<1.2)
Cyclohexane	ND (<9.9)	ND (<390)	ND (<12)	ND (<2,900)	ND (<25)	ND (<2,600)	ND (<25)	ND (<2,900)	ND (<0.50)	41.9	ND (<0.50)	6.1 J	ND (<0.50)	ND (<3.8)
Dibromochloromethane	ND (<3.8)	ND (<170)	ND (<4.7)	ND (<1,200)	ND (<9.4)	ND (<1,100)	ND (<9.4)	ND (<1,300)	ND (<0.19)	ND (<3.4)	ND (<0.19)	ND (<2.5)	ND (<0.19)	ND (<1.6)
Dichlorodifluoromethane	ND (<15)	ND (<240)	ND (<19)	ND (<1,800)	ND (<38)	ND (<1,600)	ND (<38)	ND (<1,800)	ND (<0.75)	ND (<5.0)	ND (<0.75)	ND (<3.6)	ND (<0.75)	ND (<2.4)
Ethylbenzene	817	2,520	56.7	1,560 J	62.3	1,280 J	59.3	1,380 J	2	84	ND (<0.20)	16.0	0.45 J	5.5
Freon 113	ND (<14)	ND (<260)	ND (<17)	ND (<1,900)	ND (<34)	ND (<1,700)	ND (<34)	ND (<2,000)	ND (<0.69)	11 J	ND (<0.69)	5.3 J	ND (<0.69)	3.9 J
Isopropylbenzene	23.6 J	601 J	ND (<5)	ND (<1,100)	ND (<10)	ND (<950)	ND (<10)	ND (<1,100)	ND (<0.20)	11 J	ND (<0.2)	ND (<2.1)	ND (<0.20)	ND (<1.4)
m,p-Xylene	1260	7,050	87.0	3,000 J	108	2,420 J	109	2,890 J	3.7	165	0.49 J	34.3	0.91 J	12.5
Methyl Acetate	ND (<42)	ND (<430)	ND (<52)	20,500	ND (<100)	10,300	ND (<100)	17,300	ND (<2.1)	ND (<8.8)	ND (<2.1)	ND (<6.4)	13.2	ND (<4.2)
Methyl Tert Butyl Ether	ND (<6.1)	ND (<170)	ND (<7.6)	ND (<1,300)	ND (<15)	ND (<1,100)	ND (<15)	ND (<1300)	ND (<0.31)	ND (<3.5)	ND (<0.31)	ND (<2.5)	ND (<0.31)	ND (<1.7)
Methylcyclohexane	ND (<3.6)	ND (<200)	ND (<4.6)	ND (<1,500)	ND (<9.1)	ND (<1,300)	ND (<9.1)	ND (<1500)	ND (<0.18)	ND (<4.0)	ND (<0.18)	ND (<2.9)	ND (<0.18)	ND (<1.9)
Methylene chloride	ND (<5.3)	ND (<210)	ND (<6.6)	ND (<1,600)	ND (<13)	ND (<1,400)	ND (<13)	ND (<1600)	ND (<0.27)	ND (<4.3)	ND (<0.27)	ND (<3.1)	ND (<0.27)	ND (<2.1)
o-Xylene	633	2,790	51.6	1,330 J	59.0	1,130 J	60.6	1,210 J	1.8	65.2	ND (<0.31)	13.1	0.36 J	4.0
Styrene	ND (<3.2)	ND (<100)	ND (<4)	ND (<740)	ND (<7.9)	ND (<670)	ND (<7.9)	ND (<750)	ND (<0.16)	ND (<2)	ND (<0.16)	ND (<1.5)	ND (<0.16)	ND (<0.97)
Tetrachloroethene	ND (<5.5)	ND (<250)	ND (<6.9)	ND (<1,900)	ND (<14)	ND (<1,700)	ND (<14)	ND (<1900)	ND (<0.28)	ND (<5.1)	ND (<0.28)	ND (<3.7)	ND (<0.28)	ND (<2.4)
Toluene	490	445	41.0	ND (<1,200)	39.7 J	ND (<1,100)	38.2 J	ND (<1200)	1.4	31	ND (<0.20)	8.4	ND (<0.20)	ND (<1.6)
trans-1,2-Dichloroethene	ND (<8.4)	ND (<210)	ND (<11)	ND (<1,600)	ND (<21)	ND (<1,400)	ND (<21)	ND (<1600)	ND (<0.42)	ND (<4.3)	ND (<0.42)	ND (<3.1)	ND (<0.42)	ND (<2.0)
trans-1,3-Dichloropropene	ND (<4.0)	ND (<120)	ND (<5)	ND (<890)	ND (<10)	ND (<800)	ND (<10)	ND (<900)	ND (<0.2)	ND (<2.5)	ND (<0.20)	ND (<1.8)	ND (<0.20)	ND (<1.2)
Trichloroethene	ND (<5.8)	ND (<160)	ND (<7.2)	ND (<1,200)	ND (<14)	ND (<1,100)	ND (<14)	ND (<1200)	ND (<0.29)	ND (<3.3)	ND (<0.29)	ND (<2.3)	ND (<0.29)	ND (<1.5)
Trichlorofluoromethane	ND (<5.1)	ND (<220)	ND (<6.3)	ND (<1,700)	ND (<13)	ND (<1,500)	ND (<13)	ND (<1700)	ND (<0.25)	ND (<4.6)	ND (<0.25)	ND (<3.3)	ND (<0.25)	ND (<2.2)
Vinyl chloride	ND (<5.8)	ND (<200)	ND (<7.2)	ND (<1,500)	ND (<14)	ND (<1,300)	ND (<14)	ND (<1500)	ND (<0.29)	ND (<4.0)	ND (<0.29)	ND (<2.9)	ND (<0.29)	ND (<1.9)
Xylene (total)	1,890	9,840	139	4,340 J	167	3,550 J	169	4,100 J	5.5	230	0.49 J	47.4	1.3	16.5
Total TIC, Volatile	13,250 J	85,300 J	270 J	22,000 J	1,300 J	19,000 J	650 J	25,000 J	53 J	870 J	64 J	970 J	148.7 J	179 J
Total Volatiles (Target)	6,614	32,456	1,279	33,040	1,570	20,770	1,485	29,240	692	3,331	587	1,554	2,548	2,464

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-3. P-1 Laboratory Analytical Results

Analyte	P-1 Baseline Data		P-1 Slurry Test Data											
			Persulfate 10:1 (P1-P-10)		Persulfate 20:1 (P1-P-20)		Persulfate 40:1 (P1-P-40)		Fenton 10:1 (P1-F-10)		Fenton 20:1 (P1-F-20)		Fenton 40:1 (P1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Semivolatiles (ug/L or ug/kg)														
1,1'-Biphenyl	79.9	416 J	ND (<65)	659 J	ND (<65)	896 J	ND (<65)	613 J	ND (<0.33)	134 J	2.7	180 J	1.3 J	83.7
2,4,5-Trichlorophenol	ND (<2.2)	ND (<860)	ND (<390)	ND (<1,500)	ND (<390)	ND (<1,400)	ND (<390)	ND (<1,500)	ND (<1.9)	ND (<340)	ND (<1.9)	ND (<230)	ND (<1.9)	ND (<150)
2,4,6-Trichlorophenol	ND (<1.4)	ND (<480)	ND (<250)	ND (<850)	ND (<250)	ND (<770)	ND (<250)	ND (<860)	ND (<1.3)	ND (<190)	ND (<1.3)	ND (<130)	ND (<1.3)	ND (<83)
2,4-Dichlorophenol	ND (<1.8)	ND (<960)	ND (<310)	ND (<1,700)	ND (<310)	ND (<1,500)	ND (<310)	ND (<1,700)	ND (<1.6)	ND (<370)	ND (<1.6)	ND (<250)	ND (<1.6)	ND (<170)
2,4-Dimethylphenol	93 J	3,400	ND (<330)	ND (<2,600)	ND (<330)	ND (<2,300)	ND (<330)	ND (<2,600)	4.3 J	ND (<570)	3.6 J	ND (<380)	3.2 J	ND (<250)
2,4-Dinitrophenol	ND (<1)	ND (<870)	ND (<180)	ND (<1,500)	ND (<180)	ND (<1,400)	ND (<180)	ND (<1,600)	ND (<0.89)	ND (<340)	ND (<0.89)	ND (<230)	ND (<0.89)	ND (<150)
2,4-Dinitrotoluene	ND (<0.97)	ND (<670)	ND (<170)	ND (<1,200)	ND (<170)	ND (<1,100)	ND (<170)	ND (<1,200)	ND (<0.86)	ND (<260)	ND (<0.86)	ND (<170)	ND (<0.86)	ND (<110)
2,6-Dinitrotoluene	ND (<0.63)	ND (<650)	ND (<110)	ND (<1,200)	ND (<110)	ND (<1,000)	ND (<110)	ND (<1,200)	ND (<0.56)	ND (<260)	ND (<0.56)	ND (<170)	ND (<0.56)	ND (<110)
2-Chloronaphthalene	ND (<1.1)	ND (<800)	ND (<200)	ND (<1,400)	ND (<200)	ND (<1,300)	ND (<200)	ND (<1,400)	ND (<0.98)	ND (<310)	ND (<0.98)	ND (<210)	ND (<0.98)	ND (<140)
2-Chlorophenol	ND (<1.1)	ND (<490)	ND (<190)	ND (<860)	ND (<190)	ND (<790)	ND (<190)	ND (<870)	ND (<0.95)	ND (<190)	ND (<0.95)	ND (<130)	ND (<0.95)	ND (<85)
2-Methylnaphthalene	591	1,800	ND (<82)	4,910	155 J	6,190	ND (<82)	4,370	2.4	770	13.1	716	4.7	260
2-Methylphenol	15.8	ND (<560)	ND (<270)	ND (<990)	ND (<270)	ND (<900)	ND (<270)	ND (<1,000)	ND (<1.4)	ND (<220)	ND (<1.4)	ND (<150)	ND (<1.4)	ND (<97)
2-Nitroaniline	ND (<0.74)	ND (<360)	ND (<130)	ND (<640)	ND (<130)	ND (<580)	ND (<130)	ND (<640)	ND (<0.66)	ND (<140)	ND (<0.66)	ND (<95)	ND (<0.66)	ND (<63)
2-Nitrophenol	ND (<2)	ND (<710)	ND (<360)	ND (<1,300)	ND (<360)	ND (<1,100)	ND (<360)	ND (<1,300)	ND (<1.8)	ND (<280)	ND (<1.8)	ND (<190)	ND (<1.8)	ND (<120)
3&4-Methylphenol	14.6	ND (<820)	ND (<250)	ND (<1,400)	ND (<250)	ND (<1,300)	ND (<250)	ND (<1,500)	ND (<1.3)	ND (<320)	ND (<1.3)	ND (<210)	ND (<1.3)	ND (<140)
3,3'-Dichlorobenzidine	ND (<1.4)	ND (<550)	ND (<240)	ND (<960)	ND (<240)	ND (<870)	ND (<240)	ND (<970)	ND (<1.2)	ND (<210)	ND (<1.2)	ND (<140)	ND (<1.2)	ND (<94)
3-Nitroaniline	ND (<1.4)	ND (<440)	ND (<250)	ND (<780)	ND (<250)	ND (<710)	ND (<250)	ND (<790)	ND (<1.3)	ND (<170)	ND (<1.3)	ND (<120)	ND (<1.3)	ND (<77)
4,6-Dinitro-o-cresol	ND (<0.81)	ND (<500)	ND (<140)	ND (<880)	ND (<140)	ND (<800)	ND (<140)	ND (<890)	ND (<0.72)	ND (<200)	ND (<0.72)	ND (<130)	ND (<0.72)	ND (<86)
4-Bromophenyl phenyl ether	ND (<0.34)	ND (<290)	ND (<60)	ND (<510)	ND (<60)	ND (<470)	ND (<60)	ND (<520)	ND (<0.3)	ND (<110)	ND (<0.3)	ND (<76)	ND (<0.3)	ND (<50)
4-Chloro-3-methyl phenol	ND (<1.3)	ND (<730)	ND (<240)	ND (<1,300)	ND (<240)	ND (<1,200)	ND (<240)	ND (<1,300)	ND (<1.2)	ND (<290)	ND (<1.2)	ND (<190)	ND (<1.2)	ND (<130)
4-Chloroaniline	ND (<0.45)	ND (<360)	ND (<79)	ND (<630)	ND (<79)	ND (<570)	ND (<79)	ND (<630)	ND (<0.4)	ND (<140)	ND (<0.4)	ND (<93)	ND (<0.4)	ND (<61)
4-Chlorophenyl phenyl ether	ND (<0.48)	ND (<270)	ND (<86)	ND (<470)	ND (<86)	ND (<430)	ND (<86)	ND (<480)	ND (<0.43)	ND (<110)	ND (<0.43)	ND (<71)	ND (<0.43)	ND (<46)
4-Nitroaniline	ND (<0.81)	ND (<400)	ND (<140)	ND (<700)	ND (<140)	ND (<630)	ND (<140)	ND (<700)	ND (<0.72)	ND (<150)	ND (<0.72)	ND (<100)	ND (<0.72)	ND (<68)
4-Nitrophenol	ND (<0.95)	ND (<780)	ND (<170)	ND (<1,400)	ND (<170)	ND (<1,200)	ND (<170)	ND (<1,400)	ND (<0.84)	ND (<310)	ND (<0.84)	ND (<200)	ND (<0.84)	ND (<130)
Acenaphthene	141 J	2,930	ND (<70)	2,790	ND (<70)	3,940	ND (<70)	3,080	0.56 J	532	3.1	373	0.82 J	91.9 J
Acenaphthylene	148 J	ND (<230)	ND (<76)	ND (<410)	ND (<76)	921 J	ND (<76)	ND (<410)	ND (<0.38)	202 J	ND (<0.38)	141 J	ND (<0.38)	76.8 J
Acetophenone	ND (<0.42)	ND (<360)	ND (<75)	ND (<640)	ND (<75)	ND (<580)	ND (<75)	ND (<640)	2.2 J	ND (<140)	1.7 J	ND (<95)	0.85 J	ND (<62)
Anthracene	106 J	5,260	ND (<80)	3,550	ND (<80)	6,110	ND (<80)	6,250	ND (<0.4)	1,340	1.0 J	607	ND (<0.40)	152 J
Atrazine	ND (<0.18)	ND (<500)	ND (<33)	ND (<870)	ND (<33)	ND (<790)	ND (<33)	ND (<880)	ND (<0.16)	ND (<190)	ND (<0.16)	ND (<130)	ND (<0.16)	ND (<85)
Benzaldehyde	ND (<0.3)	ND (<630)	ND (<53)	ND (<1,100)	ND (<53)	ND (<1,000)	ND (<53)	ND (<1,100)	9.0	ND (<250)	12.5	ND (<170)	24.3	ND (<110)
Benzo(a)anthracene	67.6	7,120	ND (<71)	4,980	ND (<71)	10,900	ND (<71)	11,300	ND (<0.36)	1,890	0.93 J	1,080	0.55 J	361
Benzo(a)pyrene	45	5,750	ND (<73)	4,510	ND (<73)	9,120	ND (<73)	8,790	ND (<0.37)	1,560	0.49 J	949	ND (<0.37)	320
Benzo(b)fluoranthene	24.1	4,180	ND (<120)	3,610	ND (<120)	8,050	ND (<120)	6,720	ND (<0.59)	1,260	ND (<0.59)	725	ND (<0.59)	255
Benzo(g,h,i)perylene	22	1,760	ND (<84)	2,500	ND (<84)	4,760	ND (<84)	4,340	ND (<0.42)	738	ND (<0.42)	453	ND (<0.42)	154 J
Benzo(k)fluoranthene	29.6	5,380	ND (<84)	2,690	ND (<84)	5,170	ND (<84)	6,020	ND (<0.42)	1,180	0.45 J	673	ND (<0.42)	220
bis(2-Chloroethoxy)methane	ND (<0.73)	ND (<370)	ND (<130)	ND (<650)	ND (<130)	ND (<590)	ND (<130)	ND (<660)	ND (<0.65)	ND (<140)	ND (<0.65)	ND (<97)	ND (<0.65)	ND (<64)
bis(2-Chloroethyl)ether	ND (<0.6)	ND (<290)	ND (<110)	ND (<500)	ND (<110)	ND (<460)	ND (<110)	ND (<510)	ND (<0.53)	ND (<110)	ND (<0.53)	ND (<75)	ND (<0.53)	ND (<49)
bis(2-Chloroisopropyl)ether	ND (<0.83)	ND (<430)	ND (<150)	ND (<760)	ND (<150)	ND (<690)	ND (<150)	ND (<760)	ND (<0.74)	ND (<170)	ND (<0.74)	ND (<110)	ND (<0.74)	ND (<74)
bis(2-Ethylhexyl)phthalate	ND (<0.74)	ND (<730)	ND (<130)	1,340 J	ND (<130)	ND (<1,200)	220 J	ND (<1,300)	ND (<0.66)	438 J	ND (<0.66)	ND (<190)	2.3	ND (<130)
Butyl benzyl phthalate	ND (<0.67)	ND (<430)	ND (<120)	ND (<760)	ND (<120)	ND (<690)	ND (<120)	ND (<770)	ND (<0.59)	ND (<170)	ND (<0.59)	ND (<110)	ND (<0.59)	ND (<75)
Caprolactam	ND (<0.35)	ND (<550)	ND (<63)	ND (<970)	ND (<63)	ND (<880)	ND (<63)	ND (<980)	ND (<0.32)	ND (<220)	ND (<0.32)	ND (<140)	ND (<0.32)	ND (<95)
Carbazole	81.8 J	3,570	ND (<73)	2,600	ND (<73)	3,650	ND (<73)	4,100	ND (<0.36)	870	1.4 J	353	0.47 J	90.5 J
Chrysene	64.3	7,420	ND (<50)	5,310	ND (<50)	11,200	ND (<50)	11,700	ND (<0.25)	1,950	1.0 J	1,110	0.51 J	383
Dibenzo(a,h)anthracene	9.3	416 J	ND (<110)	8										

Table 4-3. P-1 Laboratory Analytical Results

Analyte*	P-1 Baseline Data		P-1 Slurry Test Data											
	Groundwater	Soil	Persulfate 10:1 (P1-P-10)		Persulfate 20:1 (P1-P-20)		Persulfate 40:1 (P1-P-40)		Fenton 10:1 (P1-F-10)		Fenton 20:1 (P1-F-20)		Fenton 40:1 (P1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry														
(mg/L or mg/kg unless noted)														
Solids, Percent		33.5		19.8		21.8		19.6		14.8		22.2		33.7
Chromium, Hexavalent	ND (<0.010)				ND (<1.0) c						ND (<0.010)			
Iron, Ferrous	766				146						308			
Nitrogen, Nitrate ^a	ND (<0.11)				ND (<2.1)						0.14			
Nitrogen, Nitrate + Nitrite	ND (<0.10)				ND (<0.10)						0.14			
Nitrogen, Nitrite	ND (<0.010)				ND (<2.0)						ND (<0.010)			
Petroleum Hydrocarbons	27.8	309		ND (<130)	ND (<0.53)	ND (<110)		ND (<120)		384	ND (<0.53)	266		355
Phosphorus, Total	0.86				15.4						0.14			
Sulfate	2,510				3,440						4,770			
Total Organic Carbon	42.9	162,000	6,660	153,000	8,700	116,000	8,230	137,000	184	205,000	473	187,000	1,170	139,000
pH, standard units	6.23 b		10.12 b		10.17 b		10.20 b		3.10		2.89		2.57	
As(III) (ug/L)	5,880				132						6.86			
As(V) (ug/L)	14,900				767						288			
Metals (ug/L or mg/kg)														
Arsenic	13,500	ND (<6.4)	1,370	41.1	4,080	43.2	2,550	37.1	132	64.3	183	59.9	2,690	62.6
Barium	ND (<200)	ND (<64)	ND (<1,000) c	ND (<50)	ND (<1,000) c	ND (<45)	ND (<1,000) c	ND (<51)	ND (<200)	28.0	ND (<200)	25.5	ND (<400) c	ND (<30)
Cadmium	11.9	ND (<1.6)	ND (<20) c	ND (<1.3)	ND (<20) c	ND (<1.1)	ND (<20) c	ND (<1.3)	4.4	ND (<0.66)	4.4	ND (<0.56)	ND (<8.0) c	ND (<0.74)
Chromium	ND (<10)	24.1	389	19.1	778	17.9	644	18.6	10.8	17.6	21.1	19.8	188	16.4
Iron	535,000	18,500	28,600	21,500	159,000	19,100	154,000	18,700	262,000	16,400	241,000	14,900	430,000	12,900
Lead	92.4	10.3	22.0	12.1	106	9.8	126	11.0	16.5	9.2	28.1	8.3	74.7	8.9
Manganese	397		86.8	87.6	956	79.9	986	82.1	1,980	54.9	1,880	49.1	2,160	47.4
Mercury	0.93	ND (<0.054)	ND (<8.0) c	ND (<0.16)	ND (<8.0) c	ND (<0.15)	ND (<8.0) c	ND (<0.16)	ND (<0.40) c	ND (<0.095)	ND (<0.40) c	ND (<0.075)	ND (<0.40) c	ND (<0.055)
Selenium	48.8	ND (<6.4)	ND (<50) c	ND (<5.0)	ND (<50) c	ND (<4.5)	ND (<50) c	ND (<5.1)	ND (<10)	ND (<2.6)	ND (<10)	ND (<2.2)	ND (<20) c	ND (<3.0)
Silver	ND (<10)	ND (<3.2)	ND (<50) c	ND (<2.5)	ND (<50) c	ND (<2.3)	ND (<50) c	ND (<2.5)	ND (<10)	ND (<1.3)	ND (<10)	ND (<1.1)	ND (<20) c	ND (<1.5)
Thallium	ND (<10)	ND (<3.2)	ND (<50) c	ND (<2.5)	ND (<50) c	ND (<2.3)	ND (<50) c	ND (<2.5)	ND (<10)	ND (<1.3)	ND (<10)	ND (<1.1)	ND (<20) c	ND (<1.5)

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Response to EPA Comments

Response to April 4, 2007 Agency Comments (via e-mail) Scope of Work for Treatability Study

Quanta Resources Superfund Site – Operable Unit 1

Agency Comment	Response
<p>1. Objectives of the study include an evaluation of ISCO as a treatment option in source zones and impacted soils at the Site and an evaluation of whether the use of ISCO might have an impact on other contaminants at the Site. The plan seems to emphasize arsenic which is appropriate.</p> <p>However, other inorganic contaminants have been observed at the site.</p> <p>EPA recommends adding other contaminants of concern to the list of analytes, in particular lead and thallium. It is worth noting that other contaminants have been detected in SPLP tests on soil samples collected from the site, such as cadmium, barium, selenium, mercury, benzene, and chloroform.</p>	<p>Comment noted. Groundwater and soil samples (baseline and final) were analyzed for RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver) plus thallium. The groundwater and soil samples (baseline and final) were also analyzed for VOCs which included benzene and chloroform.</p>
<p>2. The selected sampling areas interestingly coincide with a region where soil arsenic concentrations (at depths >4 feet) are atypically low for the site. Because of this it may be difficult to accurately assess the impact of ISCO treatment on arsenic behavior. EPA recommends selecting soils from a region where arsenic values are >100 mg/kg and more typical for site concentrations of arsenic in soil.</p>	<p>P -1 was collected from approximately 9' below grade (bg), within an area of soil arsenic concentrations estimated to be above 100 mg/kg according to contoured soil concentrations below 4 ft bgs. A soil sample to the north of the P-1 location contained 498 mg/kg total arsenic, and a soil sample to the east contained 34.2 mg/kg total arsenic.</p> <p>SS-1 and SS-2 were moved from the location indicated in the work plan because a concrete pad was encountered at approximately 2 ft bgs. The samples were collected from approximately 6 – 8' bg and approximately 3' bg, respectively, near the MW-103 well cluster. The arsenic concentrations in soil at similar depths collected from nearby soil boring SB-103DS are:</p> <p>2.5 mg/kg (0-0.16 ft)</p> <p>2.5 mg/kg (1.4-1.9 ft)</p> <p>5.1 mg/kg (5-6 ft)</p> <p>These soil locations were selected to provide the most appropriate sample containing visible and residual coal tar, the target contaminants for the bench test. Since the presence of tar in the areas of highest arsenic contamination is limited, ISCO would likely be applied to areas with moderate arsenic contamination, such as those selected for the bench test samples. It is unlikely that ISCO would be applied to the area of highest arsenic concentrations due to the limited distribution of tar in this area. Please see response to Comment 4 for additional information regarding sample location selection and TarGOST™ results.</p>

Response to April 4, 2007 Agency Comments (via e-mail)
Scope of Work for Treatability Study

Quanta Resources Superfund Site – Operable Unit 1

Agency Comment	Response
3. As part of the planned analyses, it is proposed that both As(III) and As(V) concentrations will be determined. EPA recommends that, in addition to these fractions, total arsenic be measured. This will ensure that all forms of soluble arsenic are being captured in the As(III) and As(V) determinations.	See response to comment #1. Groundwater and soil samples (baseline and final) were analyzed for total arsenic. Groundwater samples (baseline and 20:1) were analyzed for As(III) and As(V).
4. Please clarify the depth intervals for the SS-1, SS-2, and P-1 material samples, and how these targeted depths correspond to the contamination observed during the OU1 Supplemental Investigation TarGOST™ study conducted in October 2006.	<p>The soil boring logs from the OU1 SI were used to develop the soil sample collection locations. The exact depths were not specified because the field team was to determine the exact sample depth based on field observations of targeted soil types, selecting a peat and residual tar sample from P-1, a sample with free phase tar for SS-1, and a sample with residual tar for SS-2.</p> <p>P -1 was collected from approximately 9' below grade (bg), SS-1 from approximately 6 – 8' bg, and SS-2 from approximately 3' bg. TarGOST™ responses from corresponding depths at nearby TarGOST™ boring locations are provided below. A TarGOST™ response greater than 49% RE was determined to coincide with the presence of coal tar at the Site.</p> <p>The P-1 sample is located between TL-15-09 and TL-15-08. The max TarGOST™ response of 75.9% RE at TL-15-09 was observed between 8 and 9 ft bgs. The max TarGOST™ response of 133.3% RE at TL-15-09 was observed at approximately 8 ft bgs.</p> <p>The SS-1 and SS-2 samples are located between TL-15-05 and TL-14-05. A TarGOST™ response of approximately 75% RE was observed at approximately 2-3 ft bgs in TL-15-05. A TarGOST™ response to approximately 100% RE was observed between 7 and 8 ft bgs in TL-14-05.</p>

Response to April 4, 2007 Agency Comments (via e-mail)

Scope of Work for Treatability Study

Quanta Resources Superfund Site – Operable Unit 1

Agency Comment	Response
<p>5. Please provide the monitoring well screen intervals for MW-102A, MW-102, MW-112A and MW-112B, and confirm that the selected wells are screened closest to the targeted SS-1, SS-2, and P-1 material intervals.</p>	<p>For SS-1 groundwater was collected from MW-102. MW-102 is screened from 4 – 19 ft bg and the pump was set at approximately 6 ft bg. Soil for SS-1 was collected at approximately 6 – 8 ft bg.</p> <p>For SS-2 groundwater was collected from MW-102B instead of MW-102A due to the presence of NAPL in MW-102A. MW-102 is screened from 14 – 24 ft bg and the pump was set at approximately 14 ft bg. Soil for SS-2 was collected at approximately 3 ft bg. It was not possible to collect soil and groundwater samples at similar depth intervals for SS-2 due to the presence of NAPL in the shallow well MW-102A.</p> <p>For P-1 groundwater was collected from MW-112A. MW-112B is screened from 2 – 12 ft bg and the pump was set at approximately 7 ft bg. Soil for P-1 was collected at approximately 9 ft bg.</p>
<p>6. EPA recommends also doing TOC, grain-size, TPH, and metals analyses on the baseline and final soil samples from SS-1, SS-2, and P-1 to have a better understanding of the site characteristics, as well as the potential competition for oxidant.</p>	<p>Groundwater and soil samples (baseline and final) were analyzed for TOC, TPH and RCRA metals (see response to comment #1). Baseline soil samples were analyzed for grain size. Analysis of final soil samples for grain size was not possible due to required sample volume and is not necessary because grain size will not be affected by oxidation.</p>
<p>7. Please record the groundwater sample temperatures at the time of collection to qualify the approximate formation temperature. Will the groundwater be kept on ice until test preparation? Will the slurries be kept at room temperature during the 8 to 16 hour equilibration period during the mixture preparation stage?</p>	<p>Sample temperatures were not recorded at the time of collection. Adequate formation temperature data exists from the quarterly groundwater sampling for the OU1 RI. Groundwater samples were kept on ice in the field and refrigerated in the lab until used for testing. Slurries will be operated at room temperature.</p>
<p>8. Sample homogenization will disturb VOC concentrations in the soil samples, even if plastic sealable bags are used for the actual mixing.</p> <p>Please confirm that the SS-1, SS-2, and P-1 sample locations have previous VOC concentration data from the OU1 Supplemental Investigation that can be used to corroborate the VOC sample results obtained during this treatability study.</p>	<p>Comment is acknowledged; however homogenization was necessary. The oxidation kinetics of the VOCs are well known already, and the VOCs are a relatively small proportion of the total organic mass. Therefore although disturbance did occur it had a nominal effect regarding the overall bench test objectives.</p>
<p>9. Please include a discussion of the ISCO reagent selection process and why Fenton's and sodium persulfate were selected for coal tar constituents over alternate reagents such as permanganate.</p>	<p>Permanganate is not capable of oxidizing aromatic ring structures, including BTEX and PAHs (reactions with PAHs predominantly affect alkyl groups and do not involve ring cleavage). However, both Fenton's and persulfate are powerful enough to cleave rings and thus were utilized.</p>

Response to April 4, 2007 Agency Comments (via e-mail) **Scope of Work for Treatability Study**

Quanta Resources Superfund Site – Operable Unit 1

Agency Comment	Response
<p>10. Clarify the purpose of the soil buffering test and the targeted pH range of 4 to 5. Is it to evaluate the possibility of introducing acidic solution to the formation to enhance the in-situ remediation, or to evaluate the potential effects of in-situ remedy by-products? Also clarify whether the soil buffering test mixtures will be at 50% slurries. Also clarify the purpose of the reactivity test and whether any additional measurements besides visual observations will be taken during this test (i.e. temperature).</p>	<p>Soil buffering tests were performed to ensure that optimal pH conditions could be achieved in the slurries for oxidation. An acidic pH, less than 4, is optimal for Fenton's reagent oxidation, while a basic pH, greater than 11, is required for base-catalyzed persulfate oxidation.</p> <p>The hydrogen peroxide reactivity test was performed to determine if the amount of transition metals (primarily iron) released as a result of acidification of the slurries is sufficient to initiate and sustain a reaction with dilute hydrogen peroxide. Once the hydrogen peroxide was added to the acidified slurries evidence of reaction was determined by visual observation and measurement of peroxide and iron concentrations, pH, temperature and PID headspace readings.</p>
<p>11. Clarify the catalyst that will be added for solution pH and iron concentration adjustment during the slurry testing. Will iron catalyst be used for both the Fenton's and persulfate tests, or will another catalyst be used to activate the persulfate reaction, such as heat?</p>	<p>For the Fenton's tests sulfuric acid was used to achieve a pH less than 4 in the slurries. For the persulfate tests NaOH was used to achieve a pH greater than 11 in the slurries. The results of the reactivity test indicated that the addition of an iron catalyst was not necessary for the Fenton's tests due to the native presence of iron in the slurries. Heat is not generally used in field applications because it is typically not economically feasible.</p>
<p>12. For the Fenton's reagent testing, will the slurry mixture pH be lowered as required for standard Fenton's reagent reactions, or is a "modified" Fenton's reagent proposed? The work plan discusses lowering pH only during the soil buffering test.</p>	<p>See response above to comment #11. Sulfuric acid was used to achieve a pH less than 4 in the slurries for the Fenton's tests.</p>
<p>13. Please monitor sample temperatures during the slurry tests, as it is a function of the reaction speed for both reagents.</p>	<p>Comment noted. Temperatures were monitored during the slurry tests.</p>
<p>14. The work plan describes that slurry testing will be performed until residual peroxide or persulfate has been consumed in the test reactors.</p> <p>How will this be determined and what is the estimated duration for these tests? Has any additional mid-test sampling been considered to supplement the baseline and final sample data?</p>	<p>Residual peroxide was measured with peroxide strips. Persulfate was measured by collecting a very small aliquot of liquid, then adding a couple drops of permanganate; if the permanganate disappears, then active persulfate is still present.</p>

Response to April 4, 2007 Agency Comments (via e-mail)

Scope of Work for Treatability Study

Quanta Resources Superfund Site – Operable Unit 1

Agency Comment	Response
15. Is there any additional rationale for the 50%-50% slurry mixture composition and have any other mixtures been considered?	This was primarily driven by the need to analyze multiple parameters in water samples, balanced with sample volumes that can be reasonably handled in the lab. Geo-Cleanse® wanted to maximize the soil, as it has the bulk of the contaminant mass, oxidant demand, and largest impact on ISCO. However, Geo-Cleanse® needed a "water space" above the soil to collect sufficient water to analyze all of the target analytes. Thus the 50% slurry is the best balance of these factors.
16. For the autoclave test, will the temperature and pressure selections be modified to account for anticipated field conditions as mentioned, and if so, how will this determination be made? Describe any measurements to be taken to adjust these parameters for the bench test, or whether 80-100 degrees F and 20-25 psi will be used.	These parameters were measured during the tests, and oxidant delivery rates were modified to stay within the desired ranges.
17. Page 2-1, last paragraph—EPA went to the Geocleanse website to look at their performance in using oxidation for coal tar. Their experience in New Jersey is limited to two sites (one in Jersey City). In both cases, they only performed a bench study, and the technology was never scaled up to a full-scale system. Please supply more information on why this technology did not make it to full-scale application. There is a full-scale system listed in Rochester, but the geology would be quite different there.	Geo-Cleanse® has considerable previous experience with coal tar sites, and points to case studies of field applications (pilot and full-scale) in Savannah, Augusta, and Americus, Georgia; Saginaw and Charlotte, Michigan; Charleston, SC; and Somersworth, NH. At the two NJ sites, the bench tests were successful in demonstrating potential effectiveness.
18. Page 2-2, first paragraph after bullets—It states that there will be testing for only arsenic (III) and arsenic (V). CH2M Hill performed arsenic speciation analyses, but have not supplied the EPA with those results. If you only test for arsenic (III) and arsenic (V) then you need to provide the EPA with the speciation results so that we can be assured that there are no other inorganic or organic forms at the site. The behavior of all forms of arsenic during the treatability testing is an important part of the test.	Arsenic speciation data will be provided to EPA in the OU1 Remedial Investigation Report.
19. The Work Plan needs a detailed description of the treatment technology being evaluated. Please provide a flow diagram showing the different components of the treatment system.	Detailed descriptions of the bench test systems are provided in the results report. Schematics of the soil column and autoclave tests are also included in the report.

Response to April 4, 2007 Agency Comments (via e-mail) Scope of Work for Treatability Study

Quanta Resources Superfund Site – Operable Unit 1

Agency Comment	Response
20. Section 2.2, Pages 2-2 to 2-3 – The descriptions of the different tests that will be performed on the contaminated materials should include an explanation of how these tests will be used to evaluate the efficacy of the In-Situ Chemical Oxidation technology for this site. The methods used to calculate buffering capacity, reactivity of the soil to hydrogen peroxide, and the results of the slurry, autoclave and residual saturation tests should be delineated. The criteria to be used to determine whether the study accomplished the stated goals needs to be discussed.	The bench test results' applicability to the evaluation of full-scale effectiveness of ISCO at the Quanta Resources Superfund Site will be discussed in the Draft FS Report.
21. Section 4 – The procedures for recording, storing and transmitting the data generated during the study needs to be described. Provide the procedures that will be used to analyze and interpret this data, including methods of data presentation and statistical interpretation. This section should also discuss any status or interim reports that will be produced during the study. Identify the person responsible for preparing each report as well as explain internal and external review and approval procedures, including individual roles and responsibilities.	Data and methods of evaluation are presented in the results report for the bench test. Geo-Cleanse® will prepare a report of the bench test results, and CH2M HILL will prepare a cover letter to accompany the report. A full discussion of the bench test results in the context of technology evaluation will be included in the Draft FS Report for OU1.
22. The Work Plan needs to provide estimates of the types and quantities of materials that will be generated during the study. Types of waste generated may include: unused waste not being treated; treated waste; treatment residuals; laboratory samples and extracts; used containers; contaminated debris, etc. Provide a description of the applicable regulations and an explanation of the procedures that will be used to comply with them.	Volumes of wastes generated include up to 86 kg of soil and 39 liters of water. The waste sample material will be returned to the site and disposed of as IDW. Used containers will be disposed in non-hazardous waste as per 40 CFR 261.7, "Empty Containers" provision in RCRA.
23. Appendix B – The laboratory performing the analyses described here should be identified and a list of the analytical SOPs that will be used should be provided. Also, if this work will be performed under the approved CH2MHill QAPP and FSP, these documents should be referenced; otherwise a QAPP should be prepared and submitted for this work.	Accutest and Applied Speciation performed the analyses. Figure 1-1 of QAPP has the labs utilized in the treatability study identified. Section 3 of the work plan specifies that the work will be performed under the approved CH2M HILL QAPP and the FSP addendum which was Attachment A.

Geo-Cleanse® Treatment Program
Bench Test Report



Geo-Cleanse® Treatment Program

Bench Test Report

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, NJ

Prepared for:
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October 25, 2007

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1. Introduction

CH2M HILL is currently performing a remedial investigation / feasibility study (RI/FS) for Operable Unit (OU) 1 at the Quanta Resources Superfund Site in Edgewater, New Jersey. The RI/FS is being performed in accordance with the U.S. Environmental Protection Agency Administrative Order on Consent II-Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)-2003-2012.

In-situ chemical oxidation (ISCO) has been identified as a potential remedial technology for the Site. CH2M HILL contracted Geo-Cleanse International, Inc. (GCI) of Kenilworth, New Jersey to conduct laboratory-scale bench tests with ISCO to determine the applicability of this technology at the site.

1.1. Site Information

Site characterization data provided by CH2M HILL and baseline sampling data (Section 4) indicate that the predominant organic contaminants are volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), primarily polynuclear aromatic hydrocarbons (PAHs). The VOC compounds are benzene, toluene, ethylbenzene, xylenes (collectively known as BTEX), and isopropylbenzene. Representative PAH compounds of interest include naphthalene, phenanthrene, acenaphthylene, anthracene, and pyrene.

1.2. Treatability Study Objectives

The overall objective of the bench test was to evaluate Fenton's reagent and sodium persulfate chemical oxidation, and to estimate oxidant demand, with different types of soils and different levels of contaminant impact at the site. Two types of soil (silty sand and peat) and associated groundwater present at the site were tested. The levels of contaminant impact ranged from residual sorbed-phase constituents to NAPL-phase impact. In addition, the study was also intended to evaluate the potential impact of ISCO on constituents of concern at the site other than VOCs and SVOCs (e.g., arsenic).

Specific objectives of the bench test were:

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both.
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site.
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO.
- Estimate total oxidant demand of the media.
- Determine the relative fractions of contaminants that are oxidized, volatilized, and leached during the ISCO process.

- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard may be created.

2. Oxidation Chemistry

2.1. Fenton's Reagent

Fenton's reagent is a solution of hydrogen peroxide and a ferrous iron catalyst, which together generate a hydroxyl free radical that acts as the active oxidizing agent (Haber and Weiss, 1934). The basic radical-producing mechanism is characterized as:



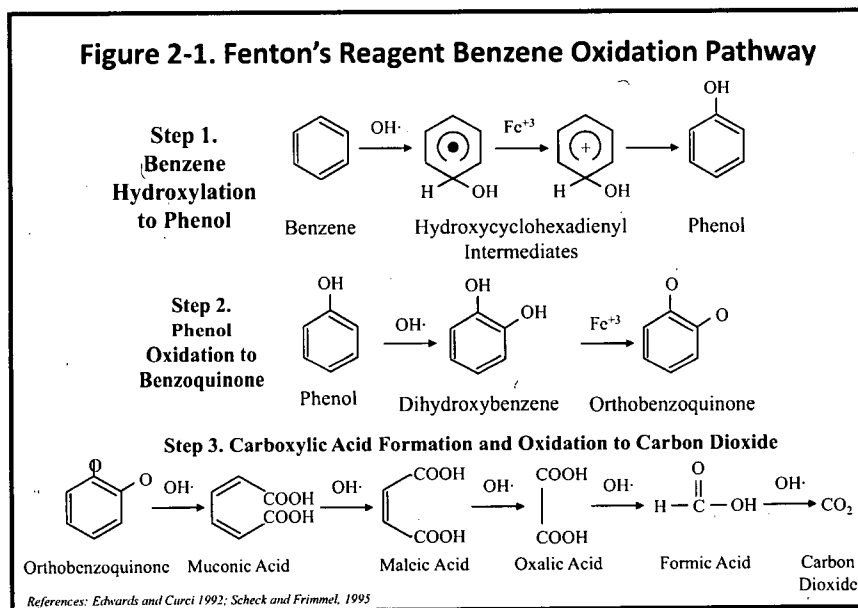
where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, $\text{OH}\cdot$ is hydroxyl free radical, OH^- is hydroxyl ion, and Fe^{+3} is ferric iron. Fenton's reagent chemistry is complex, involving a number of additional reactions producing both oxidants and reductants that contribute to contaminant destruction (e.g., Watts et al., 1999a):



where $\text{HO}_2\cdot$ is hydroperoxyl radical, HO_2^- is hydroperoxyl anion, O_2 is molecular oxygen, H^+ is hydronium ion, and H_2O is water. Additional reactions occur with organic compounds. The suite of reactions associated with Fenton's reagent is complex, but very effective at destroying many organic compounds dissolved in groundwater, sorbed to soil, or existing as non-aqueous phase liquids in subsurface environments. Fenton's reagent is generally most efficient under acidic pH conditions ($\text{pH} < 5$) because oxidation of iron (from Fe^{+2} to Fe^{+3}) by other reactions is minimized, hydrous ferric iron oxides are less likely to precipitate and remove iron from solution, and bicarbonate (which competes with the organic compounds for hydroxyl radicals) is absent. However, an effective (although not chemically optimal) Fenton's reagent system can be established at a $\text{pH} > 6$ (e.g., Watts et al., 1999b; Lindsey and Tarr, 2000).

The hydroxyl free radical generated by Fenton's reagent is a powerful, non-selective oxidant. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction. Rate constants for reactions of hydroxyl free radical with common environmental pollutants are typically in the range of 10^7 to $10^{10} \text{ M}^{-1}\text{s}^{-1}$ (e.g., Buxton et al., 1988; Haag and Yao, 1992), and 100% mineralization is generally complete in minutes. Intermediate compounds are primarily naturally occurring carboxylic acids. The end products of oxidation are primarily carbon dioxide and water. None of the injected reagents pose an environmental hazard. Unconsumed H_2O_2 naturally degrades to oxygen and water after injection.

The structure of the VOCs and PAHs at the site is similar in that all are composed of one or more benzene-type (aromatic) ring structures. The oxidation pathway of benzene is well known (Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and Johnson, 1975; Edwards and Curci, 1992; Scheck and Frimmel, 1995) and provides a model for the oxidation pathway of BTEX and isopropylbenzene. The rate constant for oxidation of benzene by $\text{OH}\cdot$ is reported as $7.8 \times 10^9 \text{ M}^{-1}\text{s}^{-1}$ (Buxton et al., 1988). Reaction of benzene with $\text{OH}\cdot$ produces short-lived and highly reactive aromatic intermediates. The initial attack is by hydroxylation to phenol with subsequent oxidation to orthobenzoquinone (Figure 2-1). Once orthobenzoquinone is formed, ring tension and oxidizing agents rapidly force fission of the aromatic ring to produce muconic acid, a linear carboxylic acid. The pathway then proceeds through a series of intermediate carboxylic acids to carbon dioxide. Hydroxyl radicals do not readily oxidize certain carboxylic acids produced as intermediate oxidation products from organic compounds, thus mineralization may be incomplete although no hazardous intermediate compounds are formed. For example, oxalic acid produced as an intermediate product from benzene is not readily oxidized in the absence of light (e.g., Karpel vel Leitner, 1997). A similar series of intermediate products, possibly also including benzoic acid, is reported for toluene (Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and Johnson, 1975).



Fenton's reagent oxidation of PAHs is well demonstrated, although the oxidation pathway is not as well known. Lee et al. (2001) and Lee and Hosomi (2001a) reported that oxidation of several PAHs, including anthracene, acenaphthylene, fluorene, benzo(a)anthracene, and benzo(a)pyrene, all produced quinones as oxidation products. The fate of the quinones during Fenton's reagent was not further determined in these studies, although quinones are also susceptible to Fenton's reagent oxidation (Chen and

Pignatello, 1997). A more detailed study of benzo(a)pyrene oxidation identified diones (the -1,6-, -3,6-, and -6,12- diones of benzo(a)pyrene) as intermediates, but that final products amounting to approximately 65% of the initial benzo(a)pyrene mass could not be identified (Lee and Hosomi, 2001b). Lee and Hosomi (2001b) confirmed that the diones are much less toxic and more readily biodegraded than the parent benzo(a)pyrene. Reisen and Arey (2002) determined that hydroxyl radicals oxidized acenaphthene and acenaphthylene in gas phase reactions rapidly to an unidentified ten carbon ring-opened product and a dialdehyde, respectively. Many other studies have concluded that PAHs are susceptible to at least partial oxidation (if not complete mineralization to carbon dioxide and water), and that the oxidation products are much more susceptible to natural degradation and are less toxic than the parent PAH compounds (Martens and Frankenberger, 1995; Kelley et al., 1997; Allen and Reardon, 2000; Nam and Kukor, 2000; Zeng et al., 2000; Lee and Hosomi, 2001a; Zappi et al., 2002). Although Fenton's reagent does temporarily reduce microbial activity, aquifer materials are not sterilized even by aggressive treatment and natural degradation processes return quickly (e.g., Chapelle, 2001; Büyüksönmez et al., 1998, 1999).

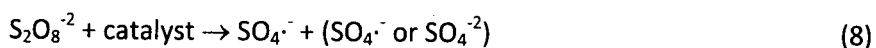
In addition to phenols, diones, and other compounds that are known to form as oxidation intermediates with Fenton's reagent, acetone and 2-butanone are often detected at both laboratory and field-scale applications of Fenton's reagent. Once formed, ketones react very slowly with hydroxyl radicals (Stefan and Bolton, 1999) and are generally recalcitrant to chemical oxidation, but are typically degraded rapidly by other (biological) processes following the ISCO treatment. The origin of the ketones in ISCO applications has not been documented. Acetone is a known oxidation byproduct of methyl tert-butyl ether (MTBE), but acetone is often detected at sites with no known MTBE impact. Ketones and phenol can be formed by hydrogen peroxide oxidation of isopropylbenzene (which is present at the site), which is the basis for a number of industrial phenol and acetone production processes. In addition, reaction of hydroxyl radicals with alkyl groups associated with the organic contaminants can produce alkoxy radicals, which may undergo spontaneous fission to produce acetone (e.g., Cederbaum et al., 1983).

2.2. Persulfate

Persulfate is a strong oxidant that has recently gained attention for ISCO applications. Persulfate exists in a number of salts, of which sodium persulfate is most commonly applied. Sodium persulfate dissolves in solution to release the persulfate anion, which is a strong oxidant:



where $\text{S}_2\text{O}_8^{-2}$ is persulfate anion and SO_4^{-2} is sulfate anion. Persulfate can be catalyzed, however, to generate persulfate radicals and hydroxyl radicals, which are more powerful oxidant than the persulfate anion:



where $\text{SO}_4^{\cdot -}$ is the persulfate radical. Potential catalysts include ferrous iron and hydrogen peroxide; elevated temperatures and elevated pH (above approximately 10) can also initiate radical formation (Block et al., 2004). Because a hydroxyl radical is formed, other associated oxidants and reductants (as shown in equations 2-6) are likely also involved.

For this bench test, base-catalyzed (also called elevated pH or alkaline catalysis) was utilized for several reasons:

- (1) In general, base-catalyzed systems are more efficient with respect to oxidant utilization, resulting in lower oxidant demand.
- (2) At elevated pH, a superoxide radical may be generated by the persulfate system. The superoxide radical may be responsible for penetrating NAPL phases and enhance oxidation (Watts et al., 1999a).
- (3) High pH imparts detergent properties that may enhance dissolution of NAPLs and enhance contact with the oxidant (Block, 2007).
- (4) Titration bench tests (Section 4.2.2) indicated the soil had relatively low buffering capacity, hence achieving a high pH condition was possible.

Persulfate oxidation of BTEX and PAHs has been demonstrated (e.g., Nadim et al., 2006; Crimi and Taylor, 2007), however the oxidation pathways and associated reactions or mechanisms have not been elucidated as well as with Fenton's reagent. Gosetti et al. (2005) found that persulfate radical-assisted oxidation of 1,5-naphthalenedisulfonate (an aromatic compound with a structure very similar to naphthalene) proceeded via a hydroxylation and ring-fission pathway similar to that of hydroxyl radical oxidation of benzene or PAHs (Figure 2-1), indicating that the intermediate products may also be similar.

3. Materials and Methods

3.1. Soil and Groundwater Collection

Soil samples were collected on March 27, 2007 by CH2M HILL representatives from three different locations using an excavator. The samples and a brief description of the soil type and anticipated level of contaminant impact for each sample are as follows:

- SS-1: Silty sand with visible NAPL.
- SS-2: Silty sand with residual contaminant impact (no visible NAPL).
- P-1: Peat with residual contaminant impact (no visible NAPL).

Immediately upon collection, GCI personnel collected baseline samples (see Section 3.2), and then transferred the remaining bulk soil into plastic-lined polyethylene buckets. The plastic liners were sealed with a tie-wrap, a lid was sealed on the bucket, and then the buckets were placed on ice. The buckets were kept sealed (other than the short time the buckets were periodically opened to prepare bench test samples) and on ice or refrigerated throughout the bench test program.

Three groundwater samples were also collected on March 27, 2007 from monitoring wells adjacent to each of the three soil sample locations. The samples were collected by CH2M HILL personnel using a dedicated polyethylene bailer. Immediately upon collection, GCI personnel collected baseline samples (see Section 2.2), and then transferred the remaining bulk water into 1-L amber glass bottles. The bottles were placed on ice at the time of collection. Upon delivery to the GCI laboratory on the same day of collection, the bottles were transferred to a refrigerator (approximately 4°C) for storage.

3.2. Baseline Sampling

Baseline samples of soil and groundwater were collected at the time the bulk soil and groundwater samples for the bench test were collected in the field. Samples were submitted to Accutest Laboratories, Inc. (Dayton, New Jersey) and to Applied Speciation and Consulting, LLC (Tukwila, Washington) for analysis (see Section 4.3.1). The analytical sample matrix, by test and analyte, are summarized in Table 4-1. The baseline soil samples were analyzed for VOCs, SVOCs, percent solids, petroleum hydrocarbons, total organic carbon, and metals. The baseline water samples were analyzed for VOCs, SVOCs, nitrite, nitrate, petroleum hydrocarbons, phosphorus, sulfate, total organic carbon, pH, arsenic speciation (As(III) / As(V)), and metals. The metals analyzed in both the soil and water samples were arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, silver, and thallium.

Table 3-1. Laboratory Analytical Sampling Matrix

Analyte and Phase	Bench Test Phase							
	Baseline		10:1 Slurries		20:1 Slurries		40:1 Slurries	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
Volatile Organic Compounds	x	x	x	x	x	x	x	x
Semivolatile Organic Compounds	x	x	x	x	x	x	x	x
Percent Solids	x		x		x		x	
Hexavalent Chromium		x				x		
Ferrous Iron		x				x		
Nitrogen, Nitrate + Nitrite		x				x		
Nitrogen, Nitrite		x				x		
Nitrate (by difference)		x				x		
Petroleum Hydrocarbons	x	x	x		x	x	x	
Phosphorus		x				x		
Sulfate		x				x		
Total Organic Carbon	x	x	x	x	x	x	x	x
pH		x		x		x		x
As(III) / As(V) Speciation		x				x		
Metals ¹	x	x	x	x	x	x	x	x

Analyte and Phase	Bench Test Phase				
	Soil Columns		Autoclave Tests		
	Soil		Soil	Water	Silica Gel
Volatile Organic Compounds	x		x	x	x
Semivolatile Organic Compounds	x		x	x	x
Percent Solids					
Hexavalent Chromium					
Ferrous Iron					
Nitrogen, Nitrate + Nitrite					
Nitrogen, Nitrite					
Nitrate (by difference)					
Petroleum Hydrocarbons					
Phosphorus					
Sulfate					
Total Organic Carbon					
pH					
As(III) / As(V) Speciation					
Metals ¹					

¹Metals = arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, selenium, silver, thallium

3.3. Laboratory Methods

3.3.1. Analytical Laboratory Methods

All of the laboratory analytical samples except the arsenic speciation samples were submitted to Accutest Laboratories (Dayton, New Jersey). The arsenic speciation samples were submitted to Applied Speciation and Consulting, LLC (Tukwila, Washington). The analytes and analytical methods utilized are summarized in Table 3-2.

Table 3-2. Laboratory Analytical Methods

Analyte	Method	Laboratory
Soil		
Volatile Organic Compounds	SW-846 8260b	Accutest
Semivolatile Organic Compounds	SW-846 8270c	Accutest
Percent Solids	EPA 160.3 M	Accutest
Petroleum Hydrocarbons	EPA 418.1 M	Accutest
Total Organic Carbon	SW-846 9060 M	Accutest
Mercury	SW-846 7471A	Accutest
Other Metals ¹ (except mercury)	SW-846 6010B	Accutest
Water		
Volatile Organic Compounds	SW-846 8260b	Accutest
Semivolatile Organic Compounds	SW-846 8270c	Accutest
Nitrogen, Nitrate + Nitrite	EPA 353.2	Accutest
Nitrogen, Nitrite	SM 19 4500NO2B	Accutest
Nitrogen, Nitrate	By difference	Accutest
Petroleum Hydrocarbons	EPA 418.1	Accutest
Phosphorus, Total	EPA 365.3	Accutest
Sulfate	EPA 300 / SW-846 9056	Accutest
Total Organic Carbon	EPA 415.1 / SW-846 9060 M / SW-846 5310B	Accutest
pH	EPA 150.1	Accutest
Chromium, Hexavalent	SW-846 7196A	Accutest
Iron, Ferrous	SM 18 3500FED	Accutest
As(III) / As(V) Speciation	Proprietary IC-ICPMS Method	Applied Speciation
Arsenic	SW-846 6020	Accutest
Mercury	SW-846 7470A	Accutest
Other Metals ¹	SW-846 6010B	Accutest

¹Metals = arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, selenium, silver, thallium

3.3.2. Soil Buffering Tests

Soil buffering tests were performed to determine the amount of acid and the amount of base that would need to be added to the slurries to achieve a pH less than 4 and a pH greater than 11, respectively. An acidic pH is optimal for Fenton's reagent oxidation, while a basic pH is required for base-catalyzed persulfate oxidation. For the acid buffering tests, a 50% solids slurry was prepared in a 100-mL Pyrex beaker using 50 g of soil and 50 mL of groundwater. The baseline pH and iron concentration were measured with a calibrated pH meter and a field test kit, respectively. A 0.5-mL aliquot of 10% sulfuric acid was added and the slurry was mixed for five minutes. For all three samples, the resulting slurry pH was less than the target pH of 4.0. The pH was then measured periodically over a three-hour period to evaluate pH buffering, and the iron concentration was determined after four hours of reaction. The experiment was conducted in triplicate for each of the three samples.

For the base buffering tests, a 50% solids slurry was prepared in a 250-mL Pyrex beaker using 150 g of soil and 150 mL of groundwater. A larger volume was utilized for the base tests to increase volume and simplify pH measurement, because the high pH resulted in disaggregation and "fluffing" of the soil in the P-1 sample. The baseline pH was measured with a calibrated pH meter. Aliquots of 10% sodium hydroxide ranging from 0.1 to 2.0 mL were added periodically; the slurry was mixed for five minutes and then allowed to settle for two minutes. The pH was then measured after each addition. The additions continued until the slurry pH was greater than 11.

3.3.3. Hydrogen Peroxide Reactivity Tests

The hydrogen peroxide reactivity test is conducted to evaluate if transition metals (primarily iron) from the soil and/or groundwater released into the acidified slurry samples is sufficient to initiate and sustain a reaction with dilute hydrogen peroxide. This test is performed by adding hydrogen peroxide to the acidified samples, and then visually inspecting for evidence of reaction (effervescence generated by peroxide decomposition) while measuring peroxide and iron concentrations, pH, temperature and PID headspace readings. As the reaction occurs, if iron decreases then the catalyst may require the addition of iron for a field application; similarly, a rapid reaction indicated by high temperatures and effervescence indicates that sufficient natural iron is present and stabilizers may be required in the catalyst formulation. For each test, a 50% solids soil slurry was prepared with 50 g of soil and 50 mL of groundwater. The slurries were acidified with 0.5 mL of 10% sulfuric acid, and then 5 mL of 35% H_2O_2 was added. The extent of reaction was observed and recorded. A second test was set up identically, except that 0.35 g of ferrous sulfate was also added to assess reactivity and compare with the reactor that did not receive additional iron.

3.3.4. Slurry Oxidation Tests

Slurry oxidation tests were performed to evaluate contaminant destruction and to assess potential effects of the oxidative treatment on other chemical parameters, such as arsenic concentration. Oxidation tests were performed at oxidant: contaminant mass ratios of 10:1, 20:1, and 40:1. Developing test conditions for the reactors to ensure that the results would be comparable among the slurries was difficult due to the overall high relative contaminant concentrations and large differences in the contaminant concentrations among the samples. This required balancing the oxidant requirements, sample size requirements for the planned analytes, differing buffering capacity of the soils, and the maximum 4-L volume of the reactors. It was not possible to balance every parameter among every test while still maintaining reasonable sample volumes. Therefore the volumes of soil and groundwater were adjusted among the tests, while still maintaining the desired oxidant: contaminant mass ratios. In order to provide sufficient liquid volume for all of the tests required for the 20:1 sample, two identical reactors were required for the 20:1 sample for each oxidant. The test conditions are summarized in Table 3-3 for the Fenton's reagent slurries and Table 3-4 for the persulfate slurries.

For the Fenton's reagent slurries (Table 3-3), the total VOC and SVOC masses were taken from the baseline sample results (see Section 4). The VOC and SVOC concentrations included the tentatively-identified compounds (TICs). The VOC and SVOC concentrations, along with the volume of groundwater and the mass of soil, were utilized to determine the total contaminant mass in the reactor. The oxidant mass equivalent to the 10:1, 20:1, and 40:1 oxidant: contaminant mass ratios were calculated, and then converted to mass of diluted peroxide. The catalyst solution was utilized to adjust pH and iron concentration as well as dilute the peroxide in order to maintain reasonable sample volumes. The volume of groundwater, mass of soil, and concentration of the oxidant solution were optimized so that the total volume of groundwater, oxidant solution, and soil did not exceed the 4-L capacity of the reactors. The concentration of peroxide was adjusted among the different dosages for a sample in order to maintain a constant volume in the reactor.

For the persulfate slurries (Table 3-4), the total VOC and SVOC masses were calculated as in Table 3-3. The oxidant mass was calculated as solid sodium persulfate; solid sodium persulfate was added to the reactors and allowed to dissolve (rather than adding the persulfate as a concentrated solution) in order to maintain reasonable total volumes. Next, the mass of solid sodium hydroxide (NaOH) necessary to establish a pH greater than 11 (see Section 3.3.2) and also to balance the acidity of the sodium persulfate (stoichiometric requirement is 2 moles of NaOH per 1 mole of persulfate) was calculated for each test. The volume of groundwater and mass of soil utilized were adjusted so that the total volume of groundwater was sufficient to dissolve the oxidant and NaOH, provide sufficient sample volume for the analytical tests, and so that the total volume did not exceed the 4-L capacity of the reactors.

Reactors consisted of 4-L HDPE bottles, which were continuously mixed and lightly sealed during the oxidant additions. The reactors could not be completely sealed due to the offgases (primarily carbon dioxide and oxygen) produced by the oxidation reactions (autoclave tests were performed separately to evaluate volatilization; see Section 3.3.6). The required volumes of soil and water were added to the reactor. The liquid pH was adjusted to less than 4 (for the Fenton's reagent tests) or greater than 11 (for the persulfate tests) by addition of sulfuric acid and NaOH, respectively. The oxidant was then added periodically while continuously mixing the reactors. The oxidant was added slowly enough to avoid excessive heat generation in the reactors. Liquids in the reactors were periodically tested for pH to ensure conditions remained optimal for each oxidant. After the oxidant additions were complete, the reactors were allowed to continue mixing until the oxidant was consumed, which was determined with peroxide test strips (for Fenton's reagent) and permanganate addition (for persulfate). Samples were then collected and submitted to analytical laboratories as summarized in Tables 3-1 and 3-2.

Table 3-3. Fenton's Reagent Slurry Test Conditions

Baseline VOCs and SVOCs			
P-1	Water (ug/L)	Soil (ug/kg)	
Total VOCs (including TICs)	19,864	117,756	
Total SVOCs (including TICs)	12,010	205,382	
Total	31,873	323,138	
Liters of groundwater =	2.5		
Kilos of soil =	1.0		
Total VOC + SVOC mass =	0.40 grams VOC + SVOC		
10:1 ratio =	4.0 grams of H ₂ O ₂ =	115.1 grams 3.5% H ₂ O ₂	
20:1 ratio =	8.1 grams of H ₂ O ₂ =	115.1 grams 7% H ₂ O ₂	
40:1 ratio =	16.1 grams of H ₂ O ₂ =	115.1 grams 14% H ₂ O ₂	
Baseline VOCs and SVOCs			
SS-1	Water (ug/L)	Soil (ug/kg)	
Total VOCs (including TICs)	34,401	3,613,700	
Total SVOCs (including TICs)	32,969	67,961,200	
Total	67,370	71,574,900	
Liters of groundwater =	0.40		
Kilos of soil =	0.40		
Total VOC + SVOC mass =	28.66 grams VOC + SVOC		
10:1 ratio =	287 grams of H ₂ O ₂ =	3,275 grams 8.75% H ₂ O ₂	
20:1 ratio =	573 grams of H ₂ O ₂ =	3,275 grams 17.5% H ₂ O ₂	
40:1 ratio =	1,146 grams of H ₂ O ₂ =	3,275 grams 35% H ₂ O ₂	
Baseline VOCs and SVOCs			
SS-2	Water (ug/L)	Soil (ug/kg)	
Total VOCs (including TICs)	22,538	5,119,600	
Total SVOCs (including TICs)	10,465	28,780,490	
Total	33,003	33,900,090	
Liters of groundwater =	0.72		
Kilos of soil =	0.72		
Total VOC + SVOC mass =	24.43 grams VOC + SVOC		
10:1 ratio =	244 grams of H ₂ O ₂ =	2,792 grams 8.75% H ₂ O ₂	
20:1 ratio =	489 grams of H ₂ O ₂ =	2,792 grams 17.5% H ₂ O ₂	
40:1 ratio =	977 grams of H ₂ O ₂ =	2,792 grams 35% H ₂ O ₂	

Table 3-4. Persulfate Slurry Test Conditions

Baseline VOCs and SVOCs		
P-1	Water (ug/L)	Soil (ug/kg)
Total VOCs + SVOCs (incl. TICs)	31,873	323,138
Liters of groundwater =	1.50	
Kilos of soil =	1.50	
Total VOC + SVOC mass =	0.53 grams VOC + SVOC	
Persulfate Demand		
10:1 ratio =	5.3 g sodium persulfate	
20:1 ratio =	10.7 g sodium persulfate	
40:1 ratio =	21.3 g sodium persulfate	
NaOH Demand - 5.0 g NaOH per kg soil + 2 moles NaOH per 1 mol persulfate		
Soil =	8 g NaOH	
Sodium Persulfate at 10:1 ratio =	1.8 g NaOH	
Sodium Persulfate at 20:1 ratio =	3.6 g NaOH	
Sodium Persulfate at 40:1 ratio =	7.2 g NaOH	
Total NaOH =	20.0 g	

Baseline VOCs and SVOCs		
SS-1	Water (ug/L)	Soil (ug/kg)
Total VOCs + SVOCs (incl. TICs)	67,370	71,574,900
Liters of groundwater =	1.50	
Kilos of soil =	0.50	
Total VOC + SVOC mass =	35.89 grams VOC + SVOC	
Persulfate Demand		
10:1 ratio =	358.9 g sodium persulfate	
20:1 ratio =	717.8 g sodium persulfate	
40:1 ratio =	1,435.5 g sodium persulfate	
NaOH Demand - 1.6 g NaOH per kg soil + 2 moles NaOH per 1 mol persulfate		
Soil =	0.8 g NaOH	
Sodium Persulfate at 10:1 ratio =	120.6 g NaOH	
Sodium Persulfate at 20:1 ratio =	241.2 g NaOH	
Sodium Persulfate at 40:1 ratio =	482.3 g NaOH	
Total NaOH =	844.9 g	

Baseline VOCs and SVOCs		
SS-2	Water (ug/L)	Soil (ug/kg)
Total VOCs + SVOCs (incl. TICs)	33,003	33,900,090
Liters of groundwater =	1.50	
Kilos of soil =	0.50	
Total VOC + SVOC mass =	17.00 grams of organics	
Persulfate Demand		
10:1 ratio =	170.0 g sodium persulfate	
20:1 ratio =	340.0 g sodium persulfate	
40:1 ratio =	680.0 g sodium persulfate	
NaOH Demand - 1.7 g NaOH per kg soil + 2 moles NaOH per 1 mol persulfate		
Soil =	0.9 g NaOH	
Sodium Persulfate at 10:1 ratio =	57.1 g NaOH	
Sodium Persulfate at 20:1 ratio =	114.2 g NaOH	
Sodium Persulfate at 40:1 ratio =	228.5 g NaOH	
Total NaOH =	400.7 g	

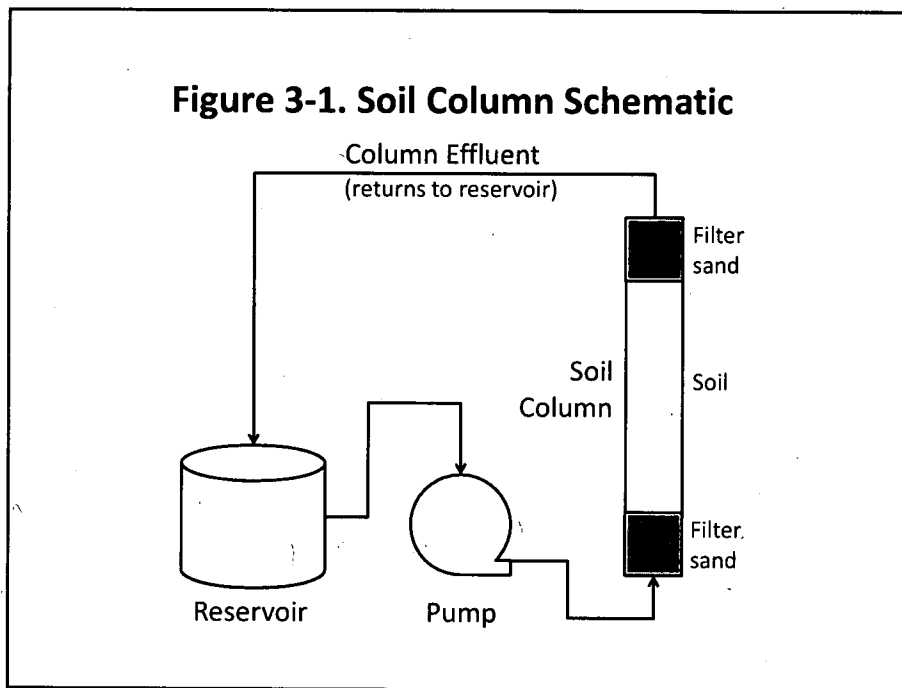
3.3.5. Soil Column (Residual Saturation) Tests

Soil column experiments were performed to evaluate NAPL destruction as an oxidant solution is passed through a soil column, and to evaluate the potential mobility of the NAPL during oxidation. One column test was performed for each oxidant, using the SS-1 soil and a 20:1 mass ratio of oxidant: contaminant. A schematic of the soil column apparatus is provided in Figure 3-1. The columns are cylindrical, constructed of polycarbonate, and have an inside diameter of 3.7 cm and length of 30 cm. Each column was filled with 180 grams of soil from SS-1, with a layer of filter sand pack at each end of the column to prevent clogging of the pump system. A chemical metering pump was utilized to flush oxidant solution through the column. Influent to the column was at the base to minimize air entrapment, and effluent from the column recycled back to an oxidant reservoir.

For the Fenton's reagent test, one liter of an acidic catalyst solution was prepared and cycled through the column until the pH of the column effluent was less than 4, to establish the acidic conditions optimal for Fenton's reagent. Concentrated (35%) hydrogen peroxide was then added to this reservoir to achieve a concentration of approximately 1% H_2O_2 . The oxidative solution was cycled through the column until the hydrogen peroxide concentration decreased to less than 0.1%, at which time the reservoir was replenished with 35% H_2O_2 . The columns were allowed to recirculate overnight and the H_2O_2 was completely expended each morning, at which time the solution was replaced with fresh oxidant solution. A total of 736 g of 35% H_2O_2 was used, equivalent to a 20:1 mass ratio of oxidant: contaminant. Pumping rates generally ranged from approximately 5 to 15 mL per minute. The range in flow-through rates was due to offgases from the oxidation reaction. Gas bubbles formed in the column, periodically reducing flow through the column. The flow rate increased once the gas bubbles cleared.

For the persulfate column, a 5% solution of sodium persulfate was prepared. The total volume of this stock solution (20:1 mass ratio of oxidant: contaminant) was 5.2 L, which was divided into two aliquots of 2.6 L each. The pH was adjusted to 11 with potassium hydroxide, and then one aliquot of the stock solution was recycled continuously through the column for three days. The solution was then replaced with the second aliquot, which was then recycled for three additional days. Pumping rates were approximately 15 mL per minute.

Visual observations of the presence or absence of NAPL, including photographs, were collected at approximately one-hour intervals for both columns. After operating the columns for one week (sufficient for consumption of the oxidant), soil samples were collected for VOC and SVOC analysis.

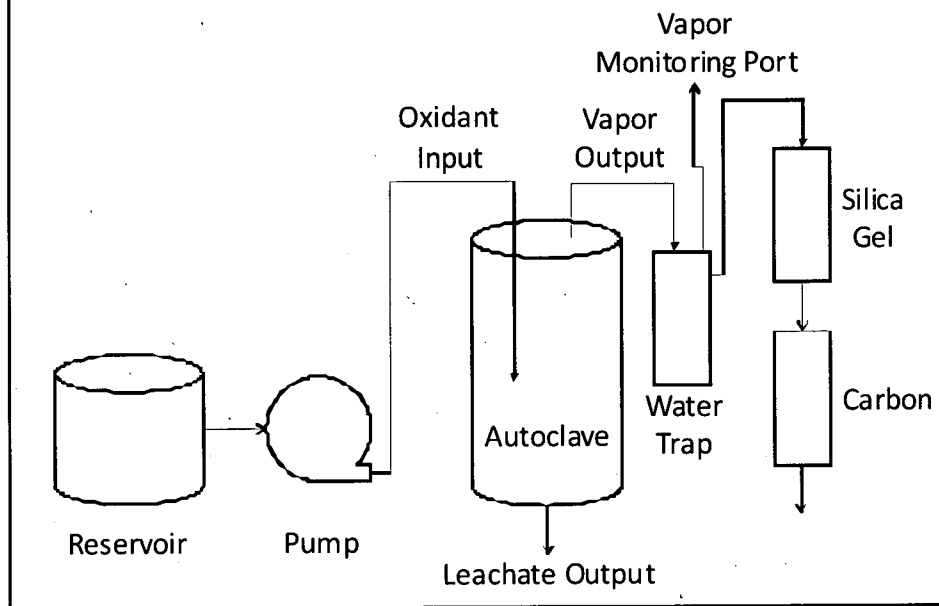


3.3.6. Autoclave Tests

Autoclave tests were conducted to provide a completely closed system and to allow quantification of volatile loss as a component of the mass balance. The autoclaves are sealed vessels in which all inputs and outputs, as well as temperature and pressure, are controlled (Figure 3-2). Offgas from the oxidation reaction is vented with a pressure-relief check valve, through a water trap (to remove liquid water in the vent line), then through silica gel (to trap water vapor) and carbon (to trap VOCs in the offgas). A vapor monitoring port on the water trap allows measurement of carbon dioxide, oxygen, and photoionization detector readings during the test to monitor progress.

The tests were performed with the SS-1 soil using a 20:1 ratio of oxidant: contaminant mass. The autoclaves were loaded with 300 g of soil. The silica gel trap contained 180 g of silica gel, and the carbon trap contained 140 g of activated carbon. For the Fenton's reagent test, an initial charge of 300 mL of acidic catalyst solution was added to the autoclave. A total of 1,227 g of 35% H_2O_2 (equivalent to 20 times the VOC and SVOC mass) was added incrementally, typically at a rate of 5-10 mL per addition in 15 to 30 minute intervals, to control the rate of offgassing and temperature. For the persulfate test, a solution of 429.4 g of sodium persulfate was dissolved in 1.5 L of water (28.6 weight percent solution), and 1 mL of 45% potassium hydroxide was added to adjust pH to greater than 11. This solution was then injected at a rate of 5-10 mL per addition in 15 to 30 minute intervals. Both autoclaves were gently mixed on an orbital shaker table to displace gas bubbles. Offgas measurements were collected at approximately one-hour intervals. At the conclusion of the experiment (seven days), samples of the treated soil, leachate, silica gel, and carbon were collected for analysis of VOCs and SVOCs.

Figure 3-2. Autoclave Schematic



4. Results and Discussion

All laboratory analytical data are summarized in Tables 4-1 through 4-3 (included in the appendix).

4.1. Baseline Soil and Groundwater Conditions

The VOCs and SVOCs detected and their relative concentrations in the baseline samples were consistent with the expected sample conditions. The most heavily impacted sample is from the SS-1 location (Table 4-1). Visible, separate-phase NAPL was present in the SS-1 sample. The total VOC and SVOC concentrations in SS-1 soil were 662,700 ug/kg and 64,769,200 ug/kg, respectively, and in groundwater the VOC and SVOC concentrations were 11,501 ug/L and 29,802 ug/L, respectively. Sample SS-2 was also heavily impacted with contaminant residuals (Table 4-2), but there was no apparent, separate-phase NAPL observed in the sample. Sample SS-2 yielded soil VOC and SVOC concentrations of 873,600 ug/kg and 34,062,890 ug/kg, respectively, and groundwater VOC and SVOC concentrations of 5,221 ug/L and 7,706 ug/L, respectively. Sample P-1 (Table 4-3) was the least impacted of the three samples. Sample P-1 yielded soil VOC and SVOC concentrations of 32,456 ug/kg and 129,182 ug/kg, respectively, and groundwater VOC and SVOC concentrations of 6,614 ug/L and 7,805 ug/L, respectively. The VOCs detected in all of the samples consisted of benzene, toluene, ethylbenzene, and xylenes (cumulatively referred to as BTEX), and isopropylbenzene. The primary SVOCs detected in the samples were PAHs consistent with coal tar, including naphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene. The predominant TICs were generally non-target PAHs, primarily indene, indane, methylnaphthalenes, and methylphenols. Among the metals, the concentration of arsenic in groundwater from P-1 (13,500 ug/L) and SS-2 (342 ug/L) exceeded the Federal Maximum Contaminant Level (MCL) of 10 ug/L. Lead (92.4 ug/L) in the P-1 groundwater sample also exceeded the MCL of 15 ug/L. Sulfate concentrations exceeded Federal Secondary Water Quality Standard (WQS) of 250 mg/L in the baseline groundwater samples from SS-2 and P-1.

4.2. Soil Buffering and Reactivity Tests

4.2.1. Acid Soil Buffering Capacity

The acid buffering test results for SS-1, SS-2, and P-1 are summarized in Figures 4-1 through 4-3, respectively. Each sample was done in triplicate to assess variability, which was found to be negligible. Addition of 0.5 mL of 10% sulfuric acid initially lowered pH to approximately 1 in all three slurries, thus further additions were unnecessary and the test was modified to evaluate pH buffering and rebound over time. Over a three-hour period after the initial additions, the pH in all three samples rebounded to approximately 3. Fenton's reagent oxidation is favored at acidic pH ranges in order to maintain iron in solution and to eliminate bicarbonate scavenging. The acid buffering capacity tests indicate that the three soil samples do not have a significant amount of carbonate solids, which react with and consume the acid and thus inhibit the acidic pH conditions optimal for Fenton's reagent treatment.

Figure 4-1. SS-1 Acid Buffering Test Results

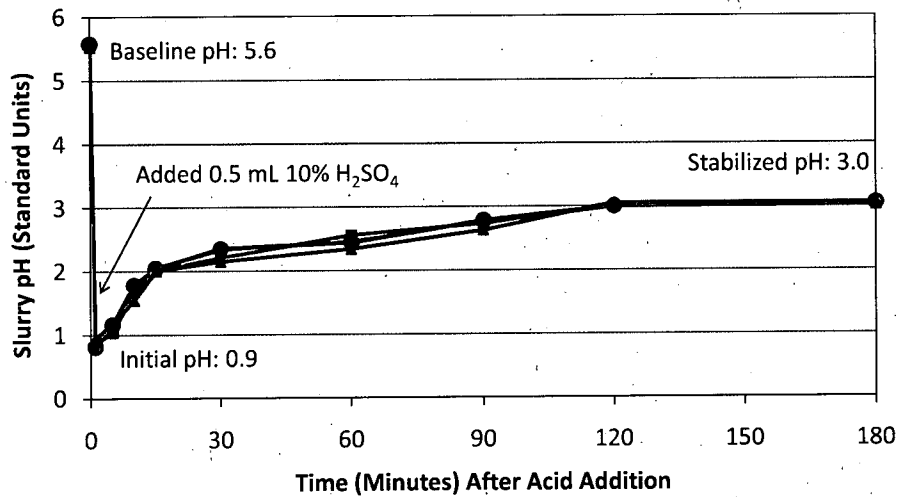
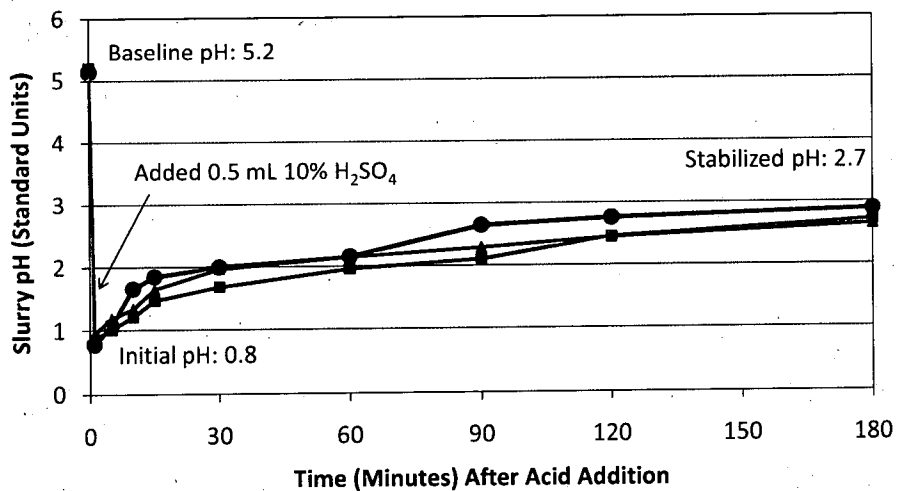
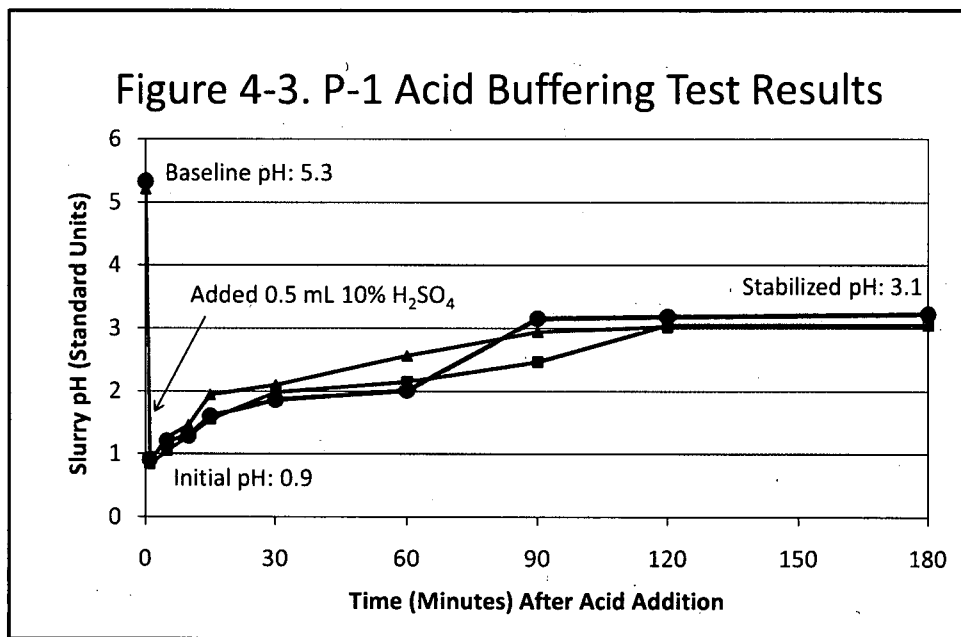


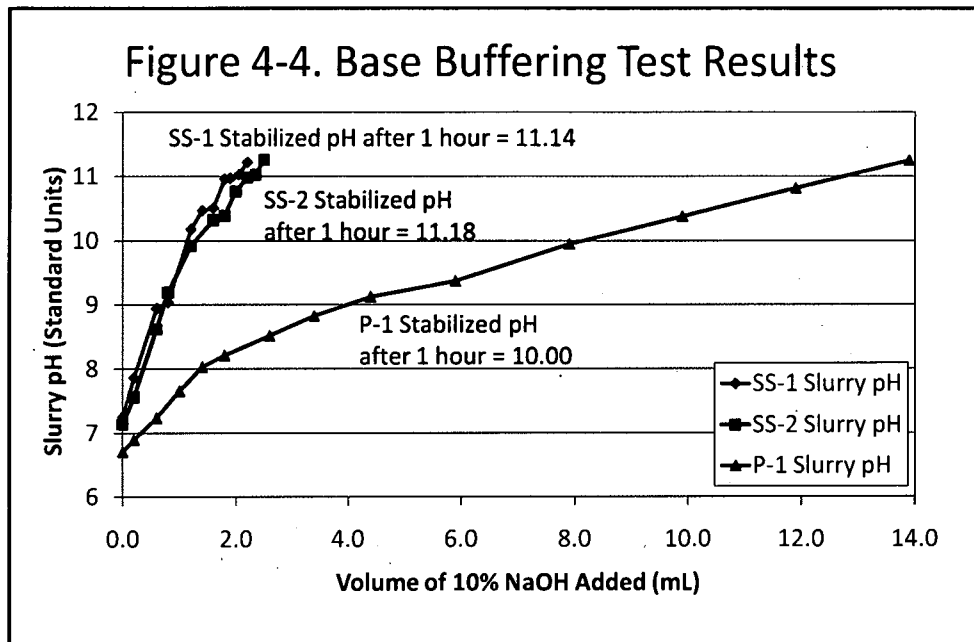
Figure 4-2. SS-2 Acid Buffering Test Results





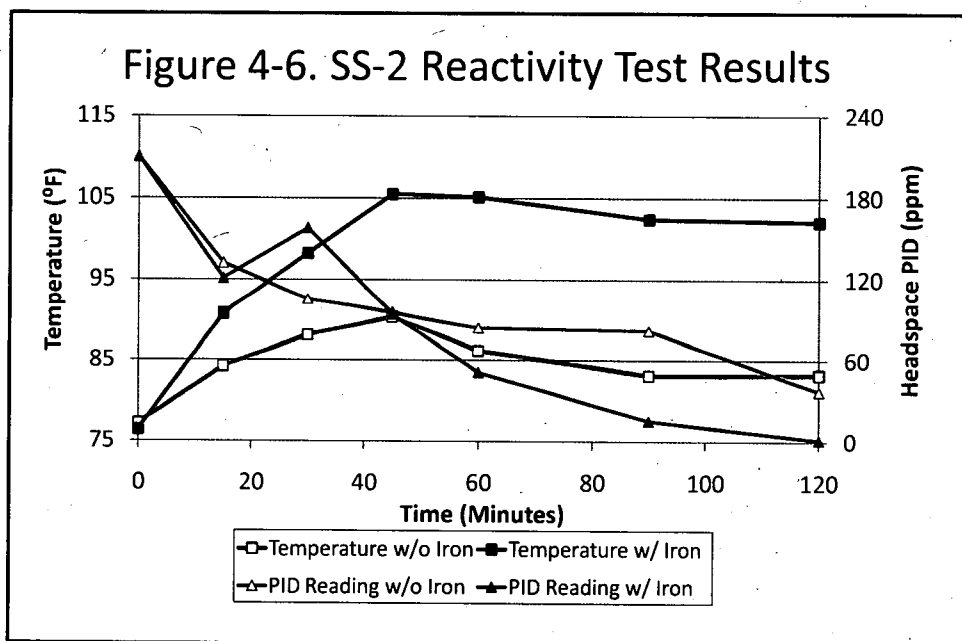
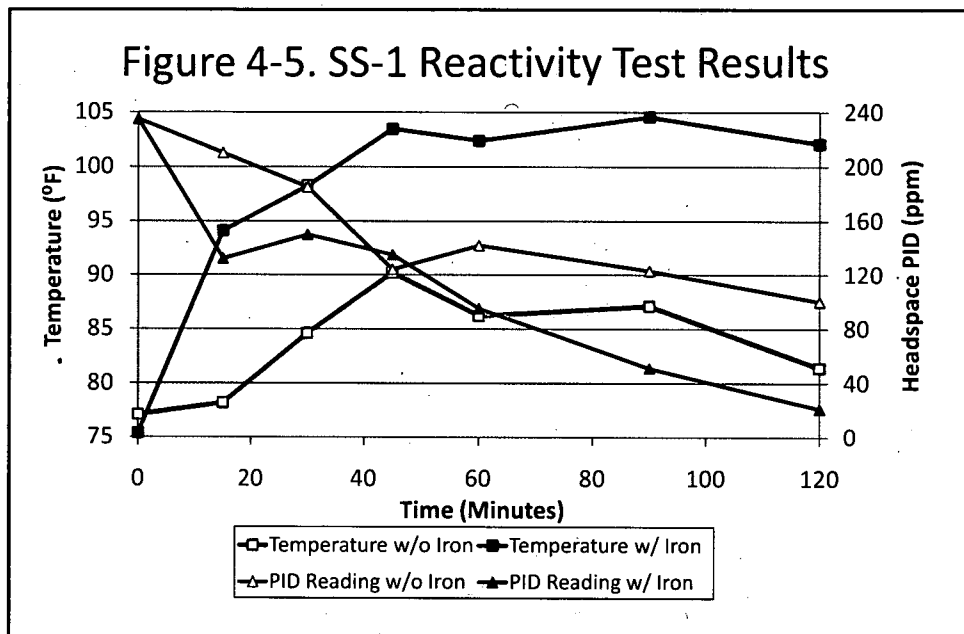
4.2.2. Base Soil Buffering Capacity

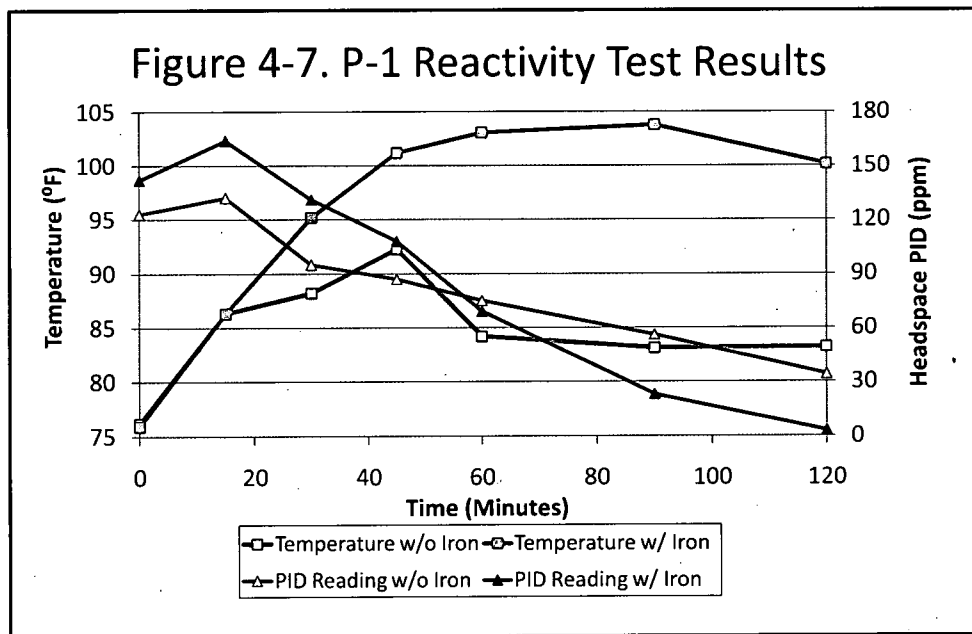
The base buffering test results for SS-1, SS-2, and P-1 are summarized in Figure 4-4. The acid buffering capacity tests performed in triplicate indicated little variability within samples, so only one aliquot was done for each sample for the base tests. In contrast to the acid buffering tests, the initial additions did not increase the slurry pH to the target levels, so incremental reagent additions continued until pH was stable above 11. Addition of 2.0-2.5 mL of 10% sodium hydroxide raised pH to greater than 11 in SS-1 and SS-2, and over the course of one hour after the last addition the pH remained stable at greater than 11. In contrast, P-1 required 14 mL of sodium hydroxide solution to raise the pH to greater than 11, and over the course of one hour after the last addition the pH dropped to approximately 10. This indicates that the SS-1 and SS-2 have little buffering capacity with respect to base addition, while the P-1 sample has high buffering capacity with respect to base addition. Because sample P-1 exhibited relatively little acid buffering capacity (Figure 4-3), the high base buffering capacity (Figure 3-4) for this sample may be due to organic acids associated with the peat matrix in this sample. The amount of base needed to establish a pH greater than 11 was calculated as grams of solid NaOH per kilogram of soil from the buffering tests for each of the three samples, and was then utilized as part of the NaOH demand for the catalyzed persulfate oxidation tests (Table 3-4).



4.3. Peroxide Reactivity Tests

The peroxide reactivity test results are presented in Figures 4-5 through 4-7. All three samples yielded evidence of good reaction without any additional iron amendment, based upon temperature elevations of 13-16 °F and PID readings reduced by 57-82% over two hours during the experiment (compare the data series with filled markers in Figures 4-5 through 4-7). Effervescence was evident, also indicating a reaction was occurring. The reaction was enhanced, however, by addition of 0.35 g of ferrous sulfate. The iron addition resulted in a temperature increase of approximately 28-29°F and a 91-99% decrease in the PID readings (compare the data series with unfilled markers in Figures 4-5 through 4-7). Overall, these results indicated that a mild reaction can be maintained by native iron released by the increased acidity associated with a Fenton's reagent treatment. Iron addition can be expected to result in a more rapid reaction.





4.4. Slurry Oxidation Tests

The laboratory analytical data for the slurry test results are tabulated in Tables 4-1 through 4-3. In the following sections, the results for the Fenton's reagent slurries are discussed first, followed by a discussion of the persulfate slurries. The relative performance of the oxidants is discussed in Section 5. For each oxidant and sample, charts are presented to illustrate the results in terms of soil concentrations, water concentrations, and contaminant mass for each dosage, and oxidation efficiency (percent destruction) as a function of formula weight for the 40:1 experiments.

Persulfate is generally considered to be more stable and have a longer lifetime in the subsurface than Fenton's reagent. Thus an expectation is that the persulfate slurries require a longer period of time to allow the oxidant to be consumed. In the case of the slurry tests conducted for this bench test, the amount of time required for both the Fenton's reagent slurries and the persulfate slurries was very similar. This is because the persulfate oxidant could all be added in a very short period of time (within an hour) and allowed to react for several days due to the slower overall reaction rate of the persulfate. However the oxidant addition for the Fenton's tests must be conducted much more slowly due to the more rapid reaction, in order to control heat production and to allow for efficient oxidant consumption. Thus the overall duration of the slurry experiments was very similar for both the persulfate and Fenton's reagent slurries.

4.4.1. Fenton's Reagent Slurries

4.4.1.1. Sample SS-1

The results for the SS-1 sample are presented on Table 4-1 and in Figures 4-8 through 4-11. Percent reductions in contaminant mass were utilized to assess destruction. The percent reductions were calculated by determining total contaminant mass (sum of all of the sample phases) in the treated samples, relative to the baseline, as calculated in Table 3-3 for example. Overall oxidation efficiency in the soil samples (which represents approximately 75% of the total contaminant mass in the baseline sample) ranged from 65-83% for the SVOCs, and 91-99.9% for the VOCs (Figure 4-8). In the aqueous phase of the slurries, the oxidation efficiency ranged from 95-99% for the SVOCs and from 93-99% for VOCs (Figure 4-9). In terms of overall contaminant mass, the oxidation efficiency ranged from 68-83% for the SVOCs and from 90-99.7% for the VOCs (Figure 4-10). All three charts of oxidation efficiency as a function of oxidant dosage (Figures 4-8 through 4-10) exhibit a pattern in which most of the oxidation occurs with the lowest oxidant dose (the 10:1 ratio). Additional oxidant results in greater oxidation, but there is an asymptotic pattern with lower contaminant mass destroyed per oxidant mass added.

The oxidation efficiency was also related to formula weight. The oxidation efficiency (percent mass reduction) was plotted as a function of the formula weight for the 40:1 test in Figure 4-11 (phenols are not plotted because they are formed as intermediate oxidation products). Benzene (formula weight 78.11) and pyrene (formula weight 202.26) are identified as representative low- and high-molecular weight compounds, respectively on Figure 4-11 and similar charts for other experiments (other compounds are shown on certain charts to identify outliers). At formula weights of approximately 160 or less, oxidation efficiency was nearly 100%. At formula weights above approximately 160, the oxidation efficiency generally decreased negatively in proportion to the formula weight. This is consistent with previous studies, which have also found that the higher molecular weight compounds are less susceptible to oxidation, due to a number of factors such as water solubility. A significant outlier in this general trend is acenaphthylene, which yielded anomalously low oxidation efficiency (46-63% with oxidant dosages between 10:1 and 40:1) in the SS-1 Fenton slurries.

The following potential intermediate compounds were observed: acetone, 2-butanone, phenol, 2-methylphenol, 3&4 methylphenol, and methyl acetate. None of these compounds have a Federal MCL. Acetone and 2-butanone were not detected in the baseline samples, but were detected at relatively low concentrations in the treated slurries. The maximum concentrations of acetone were 1,060 ug/kg in soil and 782 ug/L in water (for the 10:1 sample), and of 2-butanone were 30.6 ug/kg in soil (for the 40:1 sample) and non-detect in water (Table 4-1). Ketones are an oxidation product often detected in the treated slurries is not unusual. Other potential intermediate compounds include phenols. The concentration of phenol, 2-methylphenol, and 3&4-methylphenol do not exhibit an increasing concentration with greater oxidation (the concentration of 3&4-methylphenol increases in the 20:1 and

Figure 4-8. SS-1 Fenton Slurry Test Results - Soil

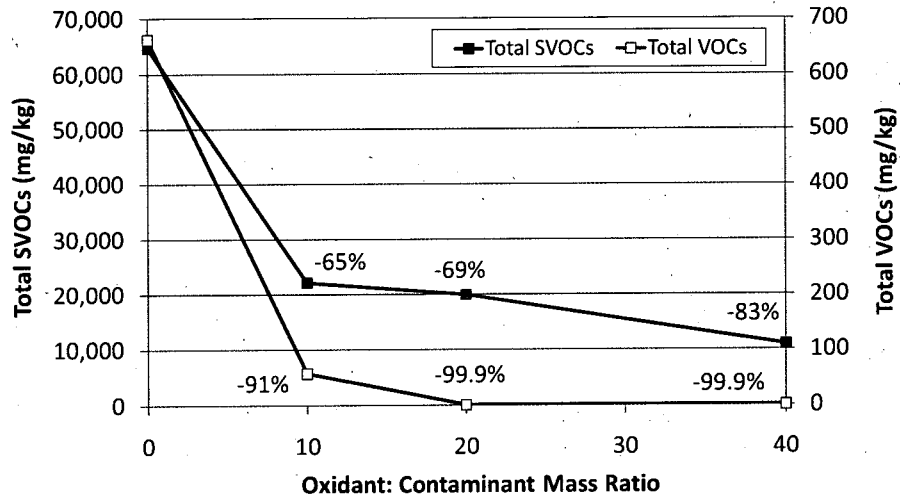


Figure 4-9. SS-1 Fenton Slurry Test Results - Water

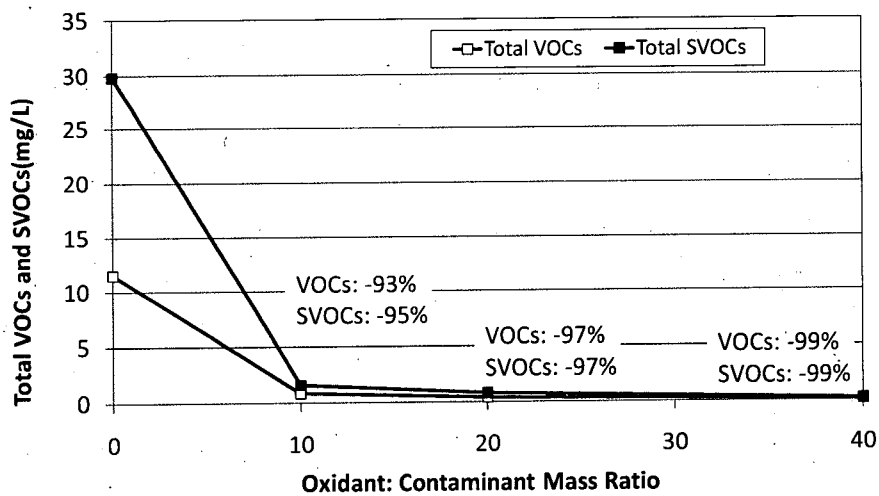


Figure 4-10. SS-1 Fenton Slurry Test Results - Mass

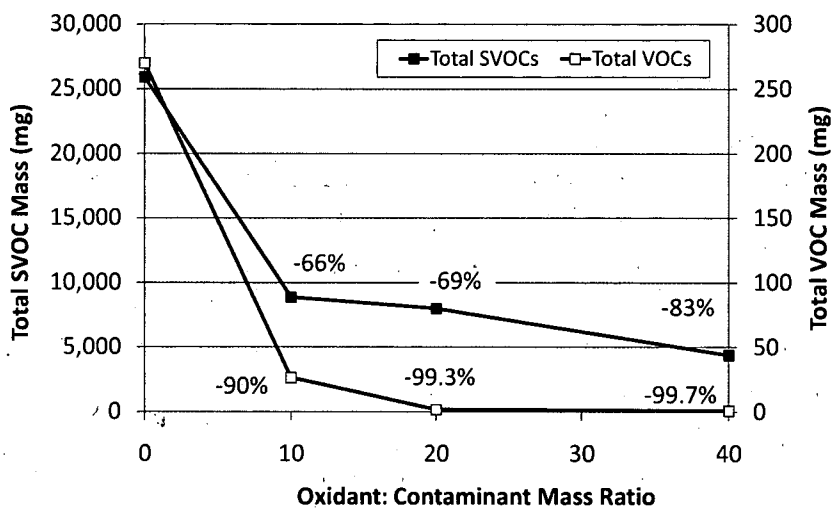
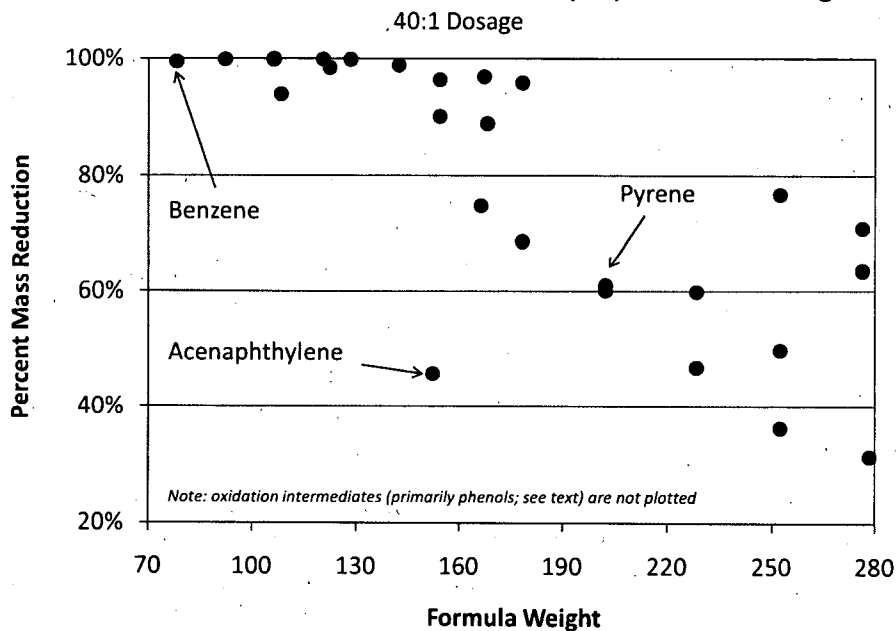


Figure 4-11. SS-1 Oxidation Efficiency by Formula Weight



40:1 slurries, but the concentrations are very close to the detection limit of the baseline sample, thus it is not clear if the concentrations in the 20:1 and 40:1 slurries represent intermediate formation). Thus if these compounds are being formed, then in these tests the compounds were also being oxidized at a rate at least as fast as their formation. Methyl acetate was detected in the soil phase of the 10:1 slurry at 5,740 ug/kg, but not in the baseline (<2,300 ug/kg) or the other slurries (<38 ug/kg). This is discussed further with the results for SS-2 (Section 4.4.1.2).

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-1. Metals were analyzed in soil and groundwater in each sample and experiment. Ferrous iron, total iron, and sulfate concentrations increased while the pH decreased in the water, as expected due to the use of an acidic catalyst solution containing ferrous sulfate. Chromium(VI) concentration increased from non-detectable (<0.010 mg/L) to 0.071 mg/L in the 20:1 sample (there is no Federal MCL for chromium(VI)). Arsenic concentration in the water samples increased from 20.6 ug/L in the baseline to a range between 459-590 ug/L. This most likely is due to acidification and leaching from the soil, because the soil concentrations decreased from 20.6 mg/kg in the baseline to a range from 14.9-16.1 mg/kg in the treated soil samples. Arsenic speciation analysis indicates that the arsenic in the treated sample was entirely in the oxidized As(V) valence state. All other metals also exhibited increases in the treated slurries, which is also most likely attributable to the acidic pH conditions and soil leaching. Sulfate concentration increased from non-detectable (<10 mg/L) to 1,710 mg/L, which exceeded the Federal Secondary WQS of 250 mg/L, due to use of ferrous sulfate and sulfuric acid reagents.

4.4.1.2. Sample SS-2

The results for the SS-2 sample are provided in Table 4-2 and summarized in Figures 4-12 through 4-15. Overall oxidation efficiency in the soil samples ranged from 59-92% for the SVOCs, and 88-97% for the VOCs (Figure 4-12). In the aqueous phase of the slurries, oxidation efficiency ranged from 45-91% for the SVOCs and from 65-82% for VOCs (Figure 4-13). In terms of overall contaminant mass, the oxidation efficiency ranged from 59-92% for the SVOCs and from 87-96% for the VOCs (Figure 4-14). As observed with SS-1, oxidation efficiency as a function of oxidant dosage (Figures 4-12 through 4-14) exhibits an asymptotic pattern of less contaminant mass destroyed per oxidant mass added with increasing dosage.

The oxidation efficiency was also related to formula weight. Oxidation efficiency (percent mass reduction) was plotted as a function of formula weight for the 40:1 test in Figure 4-13. As observed with SS-1 (Figure 4-15), at formula weights of approximately 160 or less, oxidation efficiency was generally nearly 100% (benzene was slightly lower, at 88%). At formula weights above approximately 160, the oxidation efficiency generally decreased negatively in proportion to the formula weight. In contrast to the results for SS-1, acenaphthylene did not yield anomalously low oxidation efficiency in SS-2.

The following potential intermediate compounds were observed: acetone, 2-butanone, phenol, and methyl acetate. None of these compounds have a Federal MCL. As with SS-1, acetone and 2-butanone

Figure 4-12. SS-2 Fenton Slurry Test Results - Soil

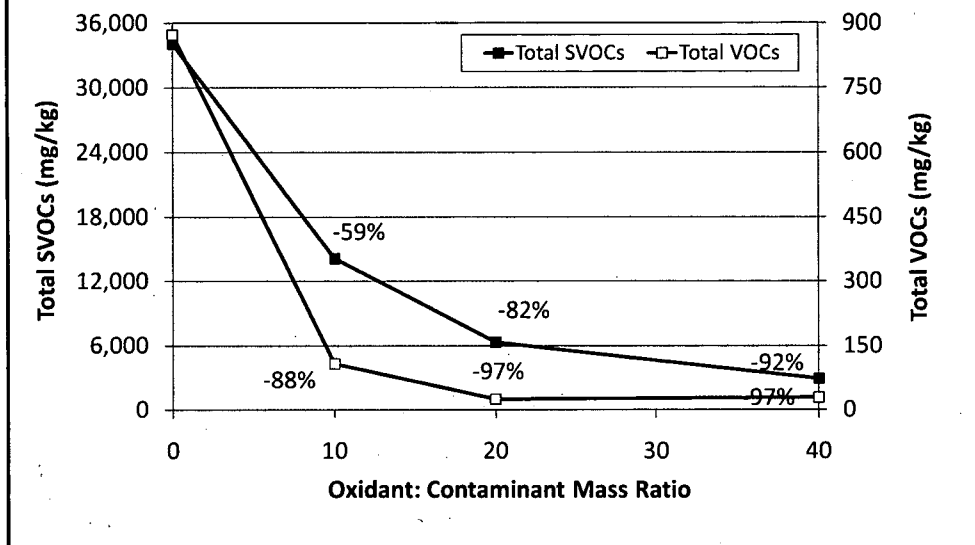


Figure 4-13. SS-2 Fenton Slurry Test Results - Water

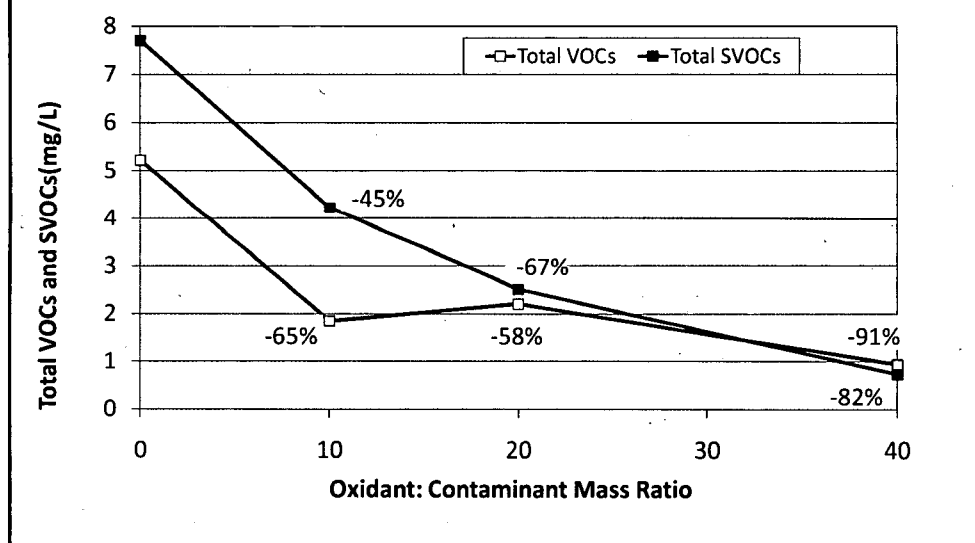


Figure 4-14. SS-2 Fenton Slurry Test Results - Mass

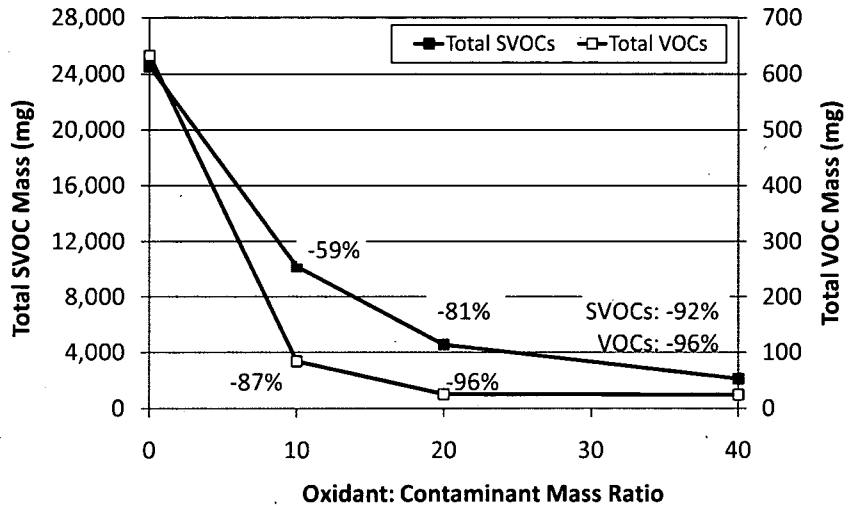
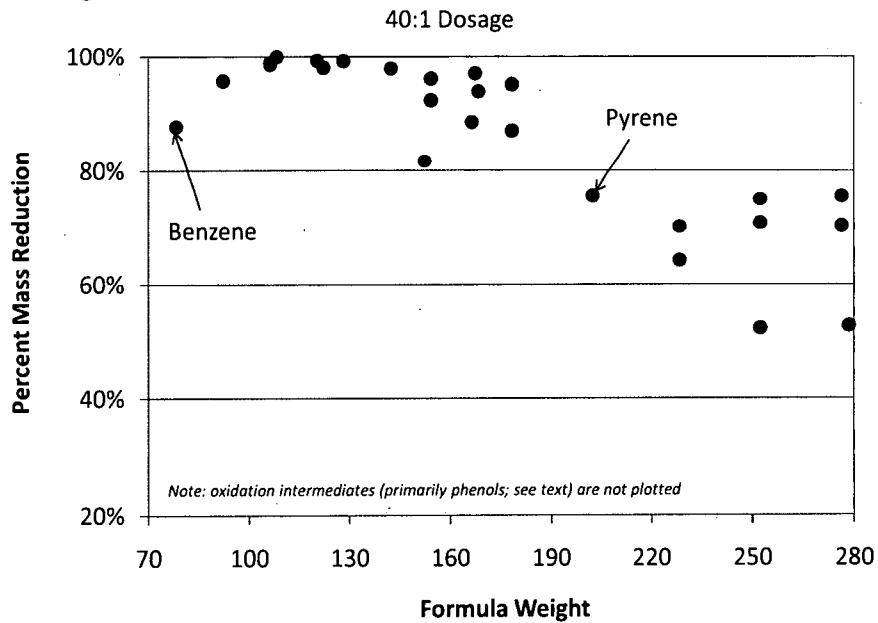


Figure 4-15. SS-2 Oxidation Efficiency by Formula Weight



were detected in the treated SS-2 slurries but were not detected in the baseline sample. Both compounds were detected only in the aqueous samples. The maximum concentrations detected were 2,100 ug/L for acetone and 42.8 ug/L for 2-butanone. Phenol was detected persistently in the treated samples at a concentration ranging from 18.8-52.3 ug/L in the aqueous phase, but was not detected in the baseline (<0.56 ug/L), indicating that formation as an intermediate product is possible. The concentrations of methylphenols decreased relative to their baseline, indicating that if they were formed then they were being oxidized at a rate faster than they were being formed.

The concentration of methyl acetate in the soil phase appears to have increased substantially relative to the baseline. Methyl acetate was not detected in the baseline (<2,600 ug/kg) or the 10:1 slurry (<14,000 ug/kg), but was detected at 6,420 ug/kg (estimated) in the 20:1 slurry and at 14,000 ug/kg in the 40:1 slurry. Methyl acetate was detected in the 10:1 slurry for sample SS-1. Methyl acetate is a known oxidation product of MTBE (Burbano et al., 2002; Carver and Brown, 2007), but MTBE is not detected at the site. It is possible that other methylated compounds could produce methyl acetate as an oxidation product, but this has not been reported previously in the literature. However in contrast to ketone intermediates, methyl acetate is susceptible to further oxidation.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-2. As expected and also observed in SS-1, the ferrous iron, total iron, and sulfate concentrations increased while the pH decreased in the water. Chromium(VI) concentration increased from non-detectable (<0.010 mg/L) to 0.069 mg/L in the 20:1 sample. Arsenic concentration in the baseline water sample was 342 ug/L and increased in two of the three treated samples, to a range between 262-928 ug/L. The increased concentrations of arsenic are most likely due to acidification and leaching from the soil. Arsenic speciation analysis indicates that the arsenic in the treated sample was primarily in the oxidized As(V) valence state (1,090 ug/L) relative to the reduced and more mobile As(III) state (6.53 ug/L). Barium, cadmium, total chromium, lead, manganese, and selenium also exhibited increases in the treated slurries, which is also most likely attributable to the acidic pH conditions and soil leaching. Sulfate concentration increased from 414 mg/L to 4,520 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to use of ferrous sulfate and sulfuric acid reagents.

4.4.1.3. Sample P-1

The results for the P-1 sample are provided in Table 4-3 and Figures 4-16 through 4-19. Overall oxidation efficiency in the soil samples ranged from 75-95% for the SVOCs, and 90-95% for the VOCs (Figure 4-16). In the aqueous phase of the slurries, the oxidation efficiency was over 99% for the SVOCs and from 62-91% for VOCs (Figure 4-17). In terms of overall contaminant mass, the oxidation efficiency ranged from 78-96% for the SVOCs and from 81-94% for the VOCs (Figure 4-18). The VOC results indicate slightly higher concentrations in the 40:1 sample than in the 10:1 and 20:1 samples, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application. All three charts of oxidation efficiency as a function of oxidant dosage (Figures 4-16 through 4-18) exhibit the

Figure 4-16. P-1 Fenton Slurry Test Results - Soil

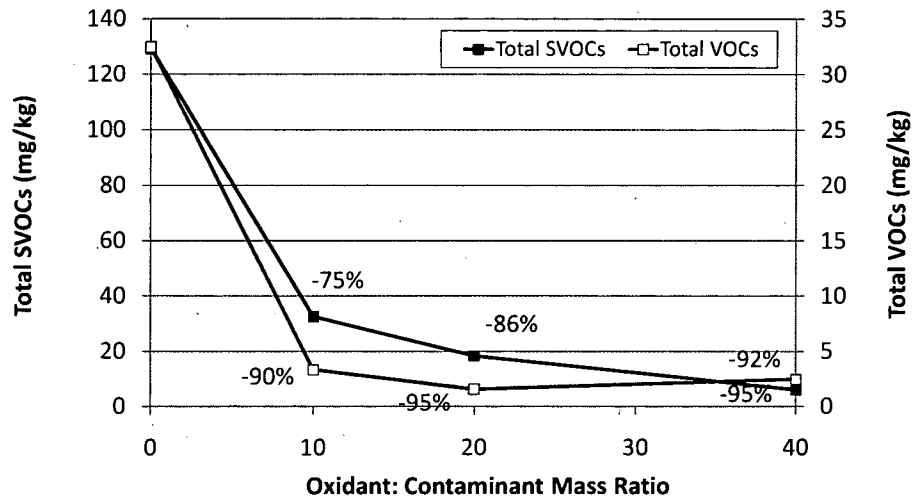


Figure 4-17. P-1 Fenton Slurry Test Results - Water

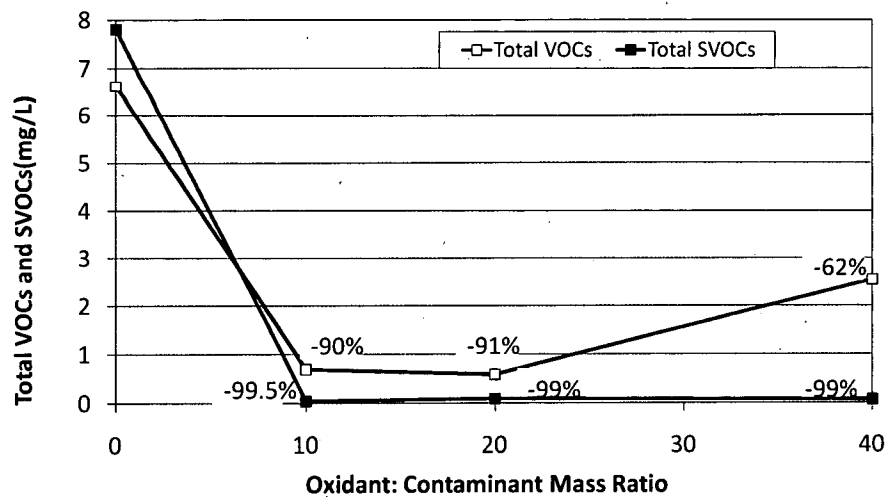


Figure 4-18. P-1 Fenton Slurry Test Results - Mass

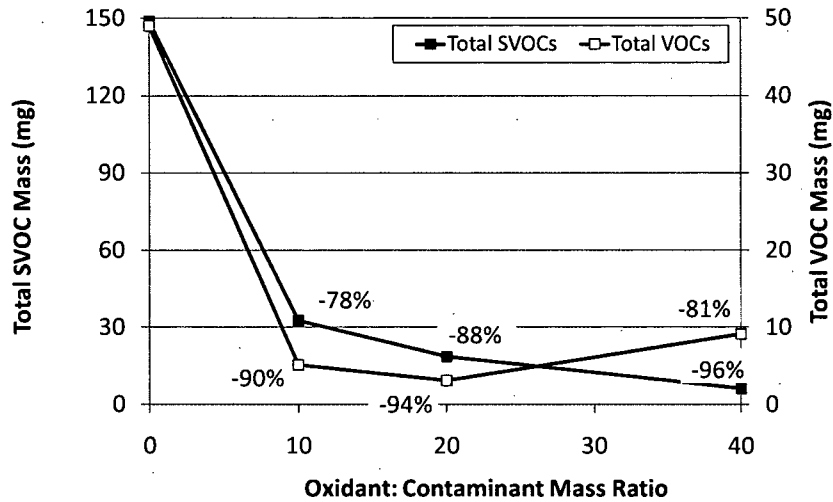
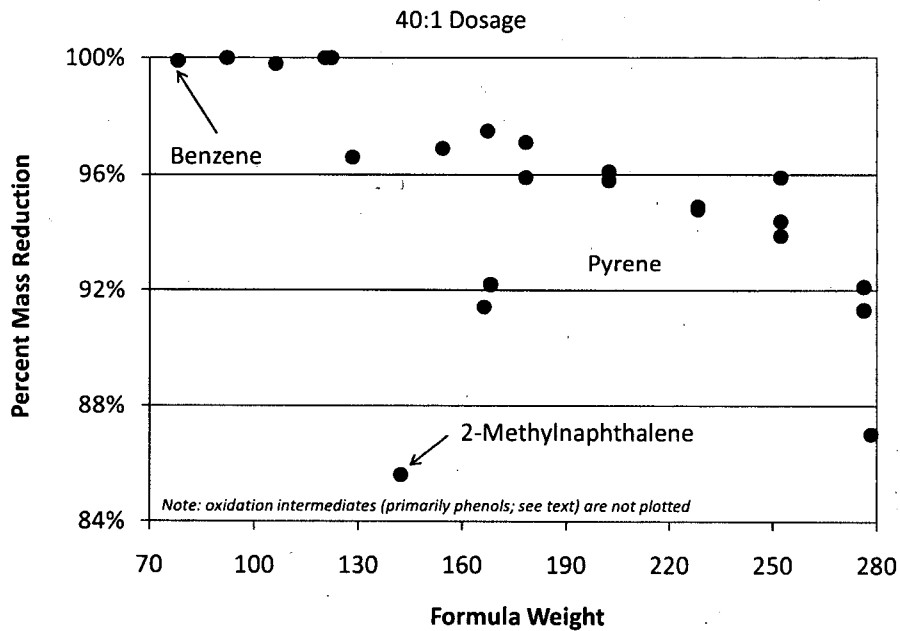


Figure 4-19. P-1 Oxidation Efficiency by Formula Weight



asymptotic pattern of less contaminant mass destroyed per oxidant mass added with increasing dosage, as observed with SS-1 and SS-2 (Figures 4-10 and 4-14, respectively). The oxidation efficiency was also related to formula weight. The oxidation efficiency (percent mass reduction) was plotted as a function of the formula weight for the 40:1 test in Figure 4-19. As observed with SS-1 and SS-2 (Figures 4-11 and 4-15, respectively), analytes with higher formula weights exhibit lower oxidation efficiencies; however, the inflection point at which oxidation efficiency decreases is at formula weight of approximately 130, which is slightly less than for SS-1 and SS-2. 2-Methylnaphthalene yielded anomalously low oxidation efficiency in P-1.

The following potential intermediate compounds were observed: acetone, 2-butanone, and phenol. None of these compounds have a Federal MCL. Acetone and 2-butanone were not detected in the baseline samples, but were detected in the treated slurries. The maximum concentrations of acetone were 2,100 ug/kg in soil and 2,340 ug/L in water (for the 40:1 sample), and of 2-butanone were 237 ug/kg in soil (for the 10:1 sample) and 172 ug/L in water (for the 40:1 sample). Ketones are an oxidation product often detected in laboratory and field implementations of ISCO (see discussion in Section 2.1), and thus their detection in the treated slurries is not unusual. Other potential intermediate compounds include phenols. Phenol was not detected in the baseline but was detected in the aqueous phase of the 40:1 sample at an estimated concentration of 2.0 ug/L; methylphenols were not detected. Thus if these compounds are being formed, then in these tests the compounds were also being oxidized at a rate at least as fast as their formation. Methyl acetate was detected in the aqueous phase of the 40:1 slurry at 13.2 ug/L, which is below the detection limit for the baseline (<42 ug/L), thus it is unclear if this is an oxidation intermediate or was present in the baseline sample below the detection limit.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-2. As expected, and also observed in SS-1, the ferrous iron, total iron, and sulfate concentrations increased while the pH decreased in the water. Chromium(VI) was not detected in the baseline or in the 20:1 sample. Arsenic concentration was elevated in the baseline (13,500 ug/L in the groundwater) and decreased in the slurries, to range between 132-2,690 ug/L. Arsenic speciation analysis indicates that the arsenic in the treated sample was primarily in the oxidized As(V) valence state (288 ug/L) relative to the reduced and more mobile As(III) state (6.86 ug/L). The decrease in arsenic concentration is likely due to coprecipitation of the oxidized As(V) with iron oxide precipitates generated by the Fenton's reagent. Total chromium and manganese concentrations increased in the treated slurries, which is also most likely attributable to the acidic pH conditions and soil leaching. Sulfate concentration increased from 2,510 mg/L to 4,770 mg/L relative to a Federal Secondary WQS of 250 mg/L, due to use of ferrous sulfate and sulfuric acid reagents.

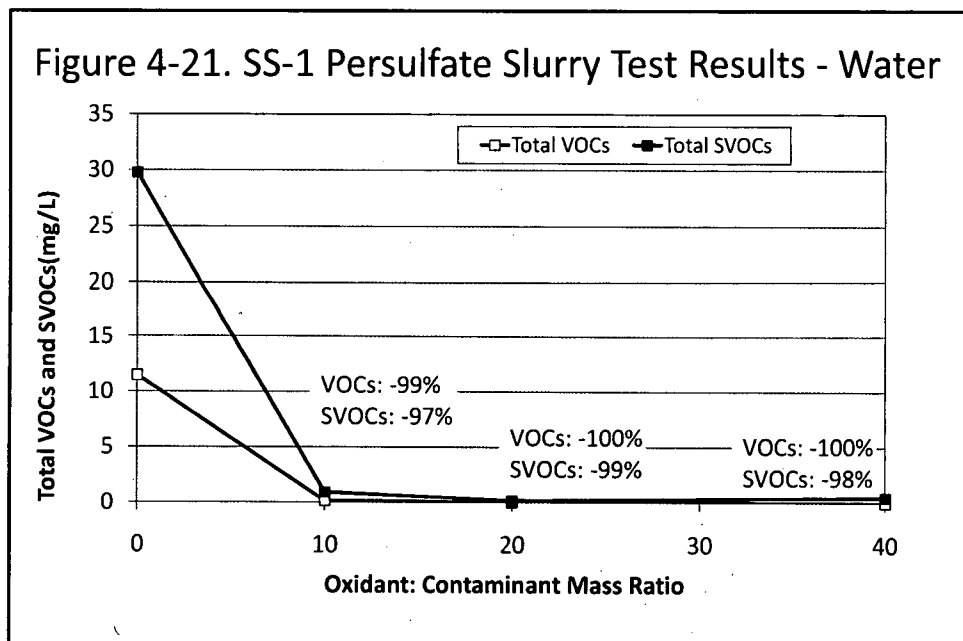
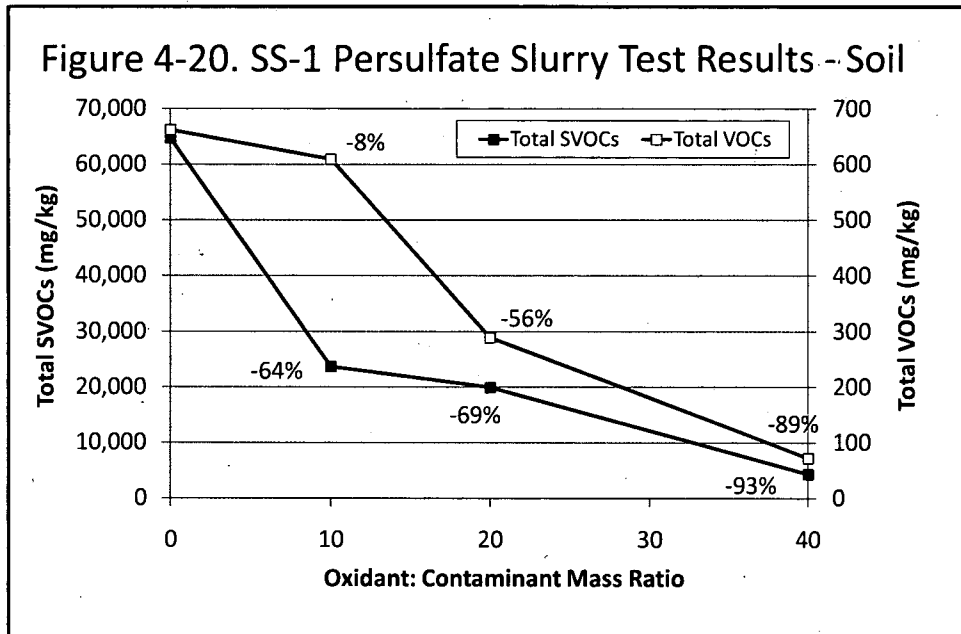


Figure 4-22. SS-1 Persulfate Slurry Test Results - Mass

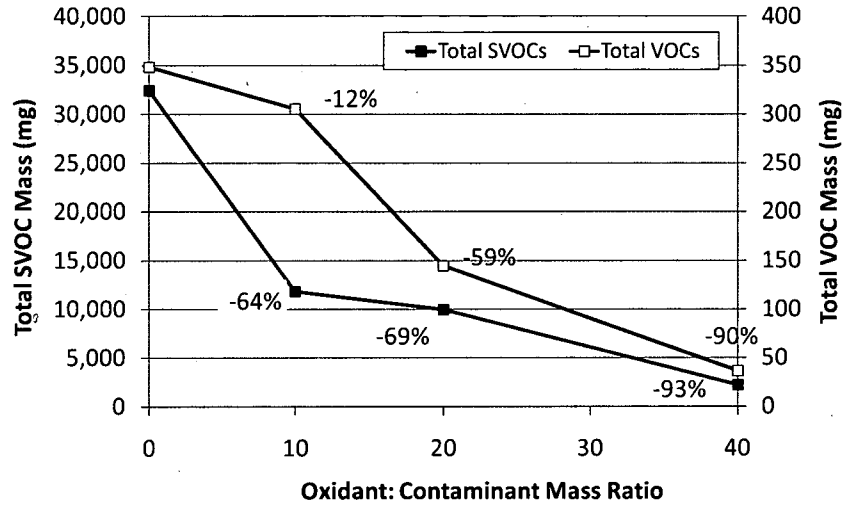
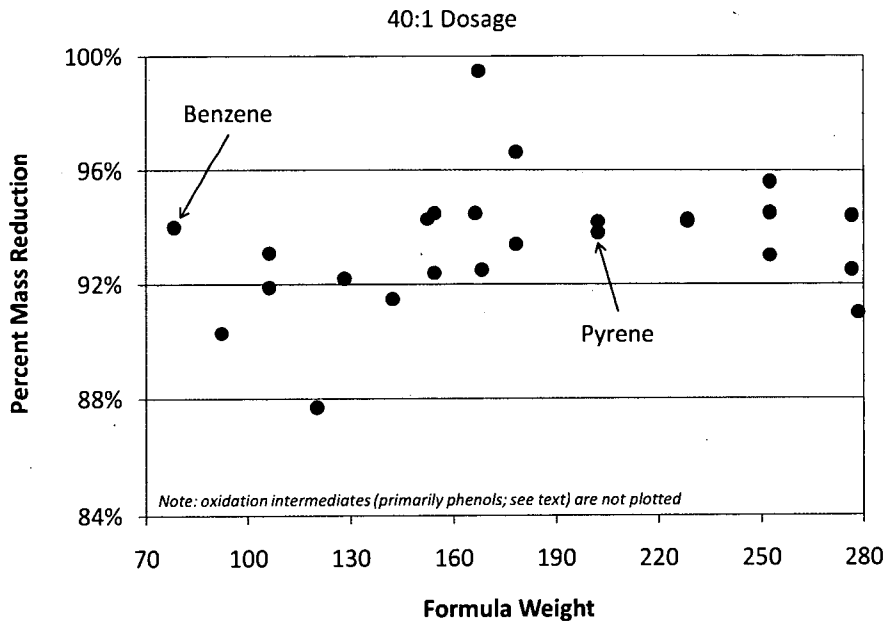


Figure 4-23. SS-1 Oxidation Efficiency by Formula Weight



4.4.2. Sodium Persulfate Slurries

4.4.2.1. Sample SS-1

The results for the SS-1 persulfate slurry samples are presented in Table 4-1 and on Figures 4-20 through 4-23. Overall oxidation efficiency in the soil samples (which represents approximately 75% of the total contaminant mass in the baseline sample) ranged from 64-93% for the SVOCs, and 8-89.9% for the VOCs (Figure 4-20). In the aqueous phase of the slurries, the oxidation efficiency ranged from 97-99% for the SVOCs and from 99-100% for VOCs (Figure 4-21). In terms of overall contaminant mass, the oxidation efficiency ranged from 64-93% for the SVOCs and from 12-90% for the VOCs (Figure 4-22). No intermediate compounds (e.g., ketones) were detected; phenol (a potential intermediate) was detected but at lower concentrations than in the baseline sample.

Oxidation efficiency for the soil and total mass as a function of oxidant dose (Figures 4-20 and 4-22) appears to be a more linear relationship compared to the asymptotic pattern observed with the Fenton's slurries. The degree of oxidation in the aqueous phase results (Figure 4-21) is too rapid to tell if the relationship is linear or asymptotic. The oxidation efficiency also appears to be unrelated to formula weight (Figure 4-23).

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-1. Metals were analyzed in soil and groundwater in each sample and experiment. Sulfate concentration increased to 62,100 mg/L and pH increased to 13.42 in the water from the use of sodium persulfate and sodium hydroxide as reagents (there are no Federal MCLs for sulfate or pH). Total arsenic concentration increased from a baseline of 20.6 ug/L to a range of 385-683 ug/L in the slurries, however no As(III) was detected in the treated sample. Lead concentrations increased from non-detectable in the baseline to a range of 1,700-5,600 ug/L in the slurries. Total chromium increased from non-detectable in the baseline to a range of 90.2-193 ug/L in the slurries, but chromium(VI) remained undetectable in the 20:1 slurry. Potential causes for increased lead and chromium concentrations were not identified. Sulfate concentrations increased from non-detectable (<10 mg/L) to 62,100 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to the persulfate reagent.

4.4.2.2. Sample SS-2

The results for the SS-2 persulfate slurry samples are presented on Table 4-2 and in Figures 4-24 through 4-27. Overall oxidation efficiency in the soil samples (which represents approximately 75% of the total contaminant mass in the baseline sample) ranged from 48-64% for the SVOCs, and 15-58% for the VOCs (Figure 4-24). The SVOC concentration in the 40:1 slurry is higher than in the 10:1 and 20:1 slurries, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application rather than a treatment efficiency factor. In the aqueous phase of the slurries, the oxidation efficiency ranged from 89-99% for the SVOCs and from 71-100% for VOCs (Figure 4-25). In terms of overall contaminant mass, the oxidation efficiency ranged from 48-64% for the SVOCs and from 16-59%

Figure 4-24. SS-2 Persulfate Slurry Test Results - Soil

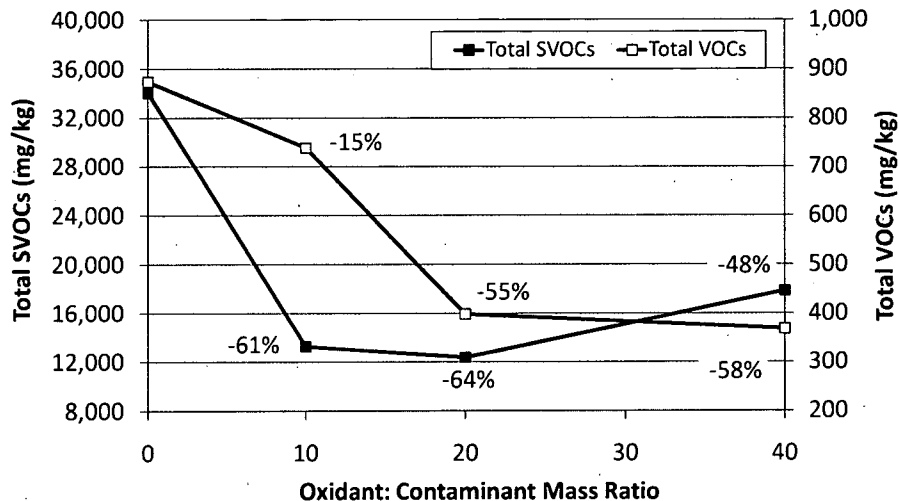


Figure 4-25. SS-2 Persulfate Slurry Test Results - Water

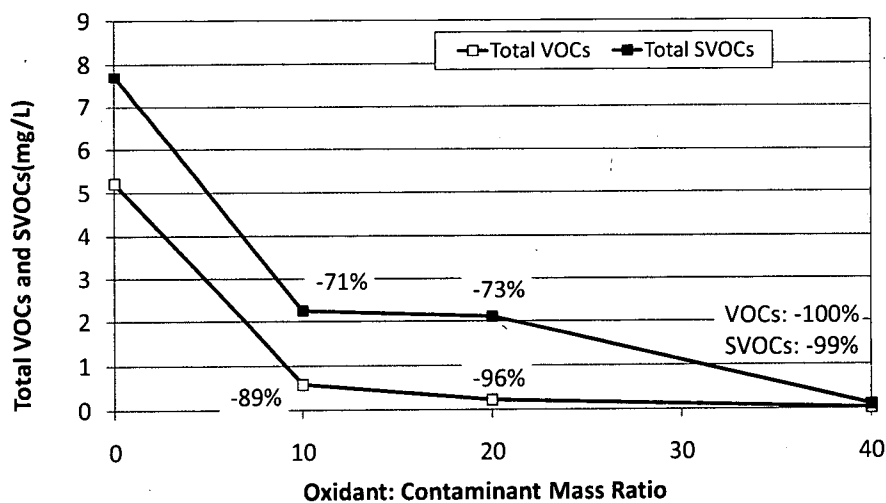


Figure 4-26. SS-2 Persulfate Slurry Test Results - Mass

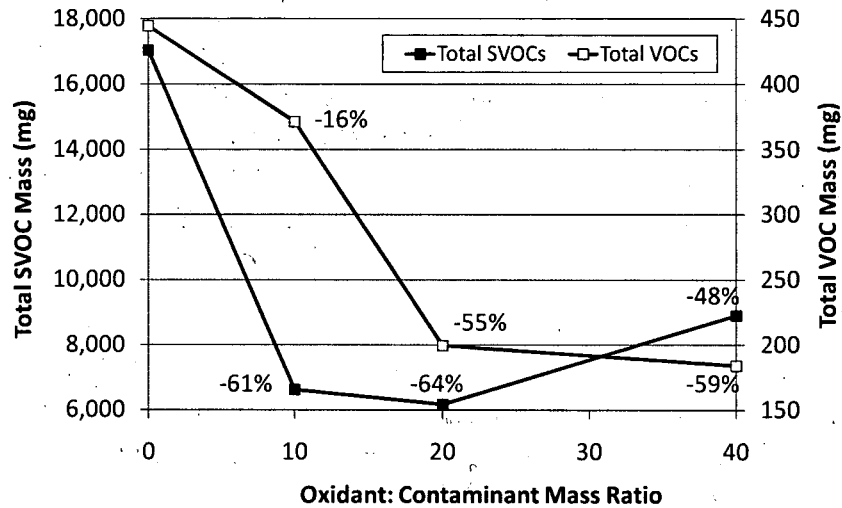
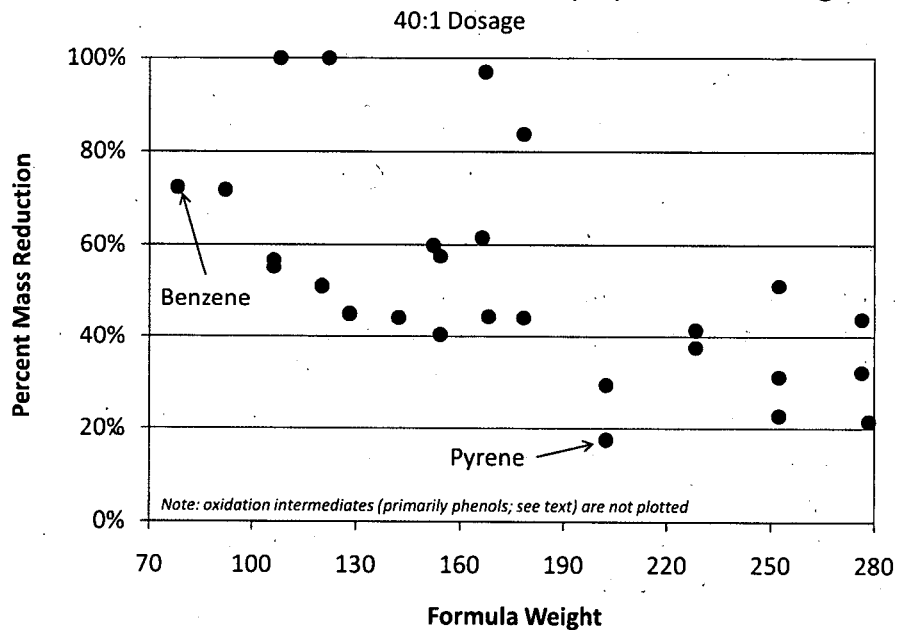


Figure 4-27. SS-2 Oxidation Efficiency by Formula Weight



for the VOCs and the kinetics were asymptotic (Figure 4-26). However, the SVOC mass in the 40:1 sample is anomalously high, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application. A plot of oxidation efficiency as a function of formula weight (Figure 4-27) indicates that there is a slightly negative relationship with higher oxidation efficiency and lower formula weights.

The following potential intermediate compounds were observed: acetone and 2-butanone. None of these compounds have a Federal MCL. Among the potential intermediate products, acetone and 2-butanone were detected in the 10:1 slurry at concentrations of 485 ug/L and 29.4 ug/L (estimated), respectively, but not detected at the higher oxidant dosages. Phenolic compounds were not detected in the treated samples.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-2. Metals were analyzed in soil and groundwater in each sample and experiment. Sulfate concentration and pH increased in the water from the use of sodium persulfate and sodium hydroxide as reagents. Total arsenic concentration increased from a baseline of 342 ug/L to a range of 480-834 ug/L in the treated slurries, but As(III) remained undetectable. Lead concentration increased from 3.9 ug/L in the baseline to a range of 6.2 to 4,280 ug/L in the treated slurries. Total chromium concentration increased from non-detectable in the baseline to a range of 137-310 ug/L in the treated slurries, with Cr(VI) increasing from non-detectable to 0.034 mg/L in the 20:1 slurry. Potential causes for increased lead and chromium concentrations were not identified. Sulfate concentrations increased from 414 mg/L to 50,600 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to the persulfate reagent.

4.4.2.3. Sample P-1

The results for the P-1 persulfate slurry samples are presented on Table 4-3 and in Figures 4-28 through 4-31. Oxidation efficiency results for the soil were variable, and the SVOC concentration exhibits an apparent increase ranging from 4-59% relative to the baseline (Figure 4-28). In contrast, the oxidation efficiency results in the groundwater were as expected, with 76-81% reduction in the VOC concentrations and 80-88% reduction in the SVOC concentrations (Figure 4-29). The soil concentration data affect the overall mass reduction (Figure 4-30). The VOCs exhibit a variable reduction of 9-39%, while the SVOCs exhibit an initial 7% decrease in the 10:1 slurry and an apparent 49-52% increase in the 20:1 and 40:1 slurries. Considering the lithology of this soil sample (peat with residual constituent concentrations), the variability in the soil results is likely the result of variable contaminant distribution between the samples prior to oxidant application coupled with an overall very low oxidation efficiency in the soil phase. The VOCs and SVOCs desorbed from the soil into the liquid phase were readily oxidized, based upon the reductions observed in the aqueous phase concentrations (Figure 4-29).

The apparent oxidation efficiency was plotted as a function of formula weight to determine if the variability was influenced by physical parameters that may correlate with formula weight (Figure 4-31).

Figure 4-28. P-1 Persulfate Slurry Test Results - Soil

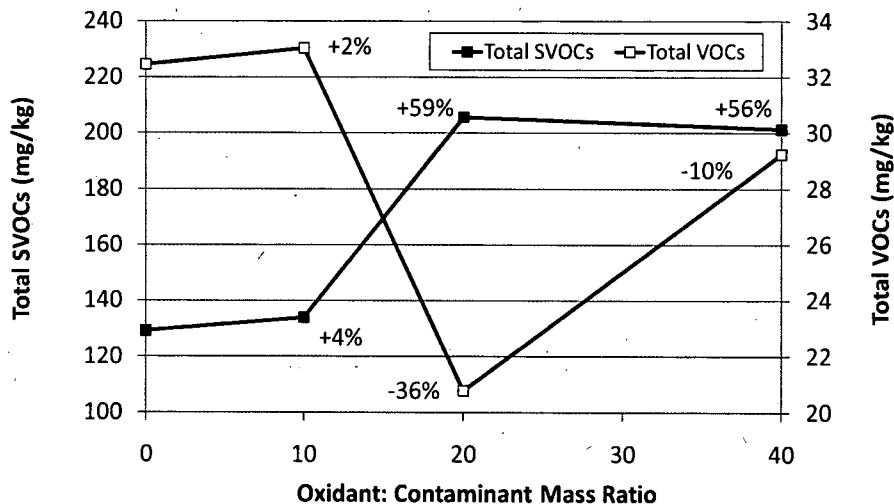


Figure 4-29. P-1 Persulfate Slurry Test Results - Water

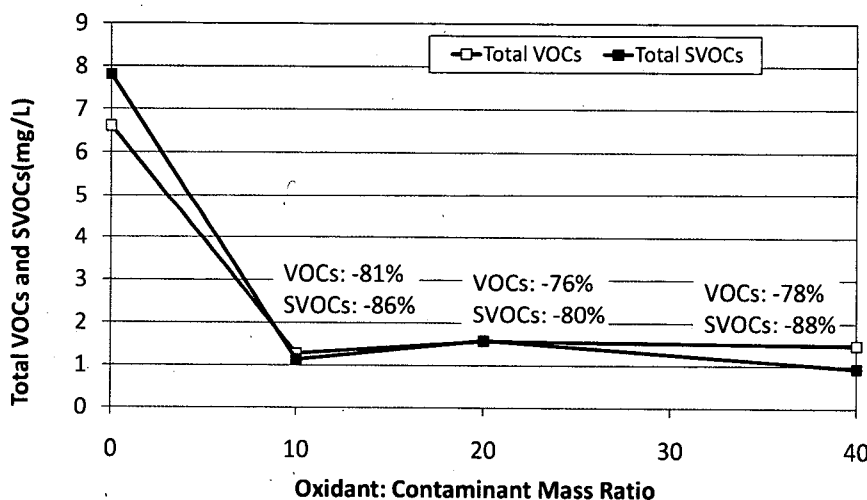


Figure 4-30. P-1 Persulfate Slurry Test Results - Mass

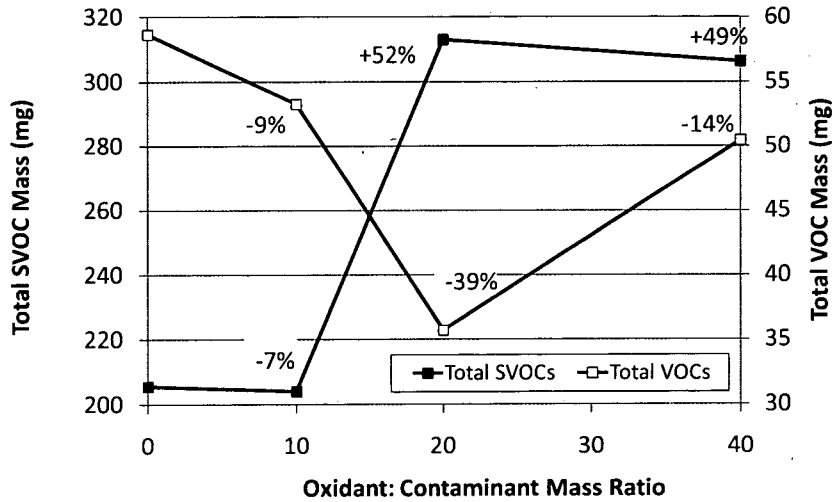
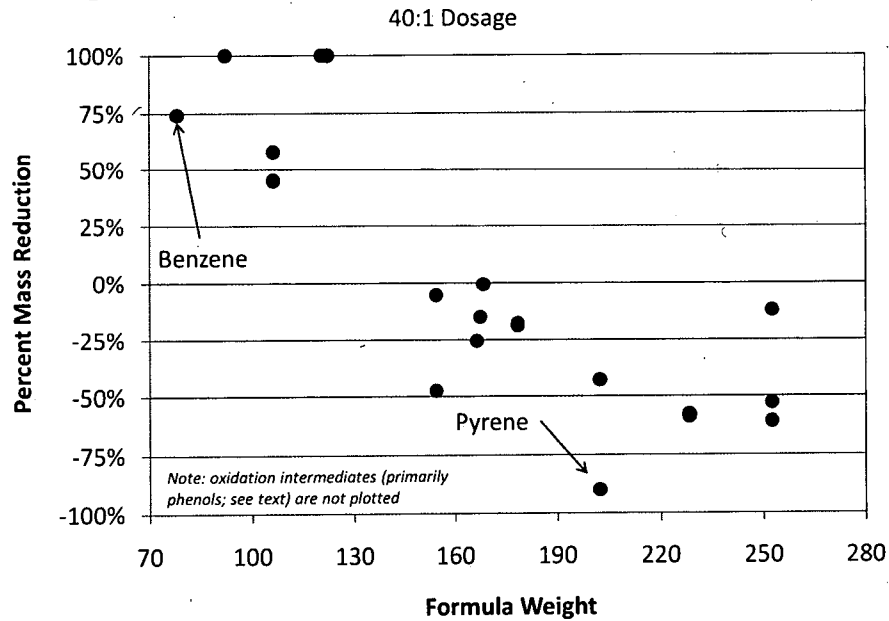
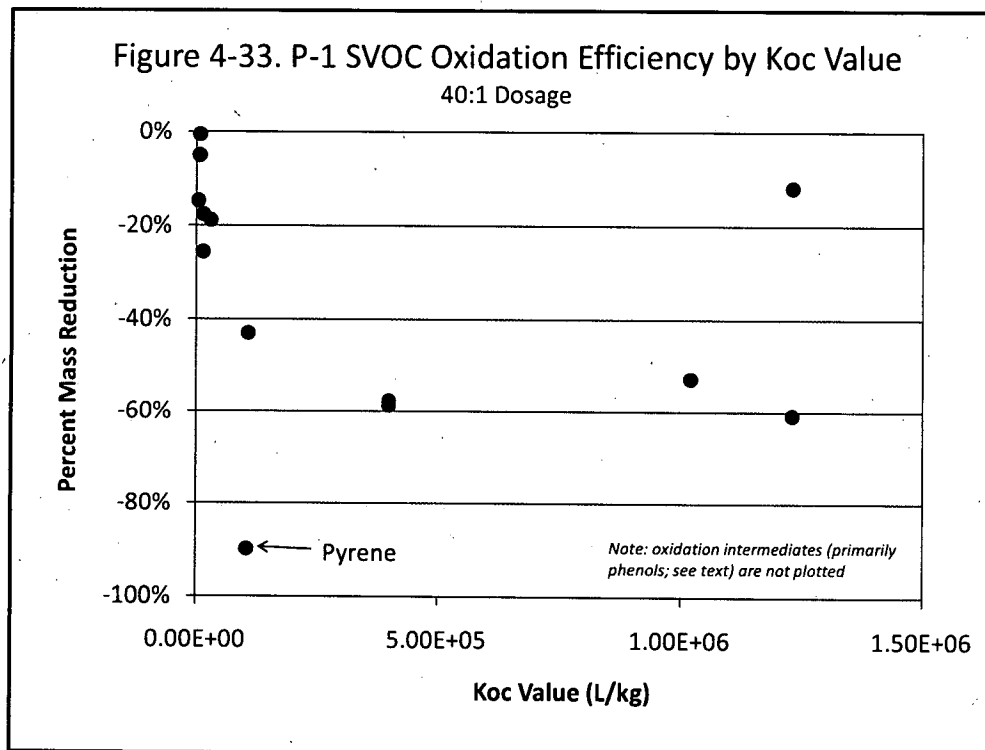
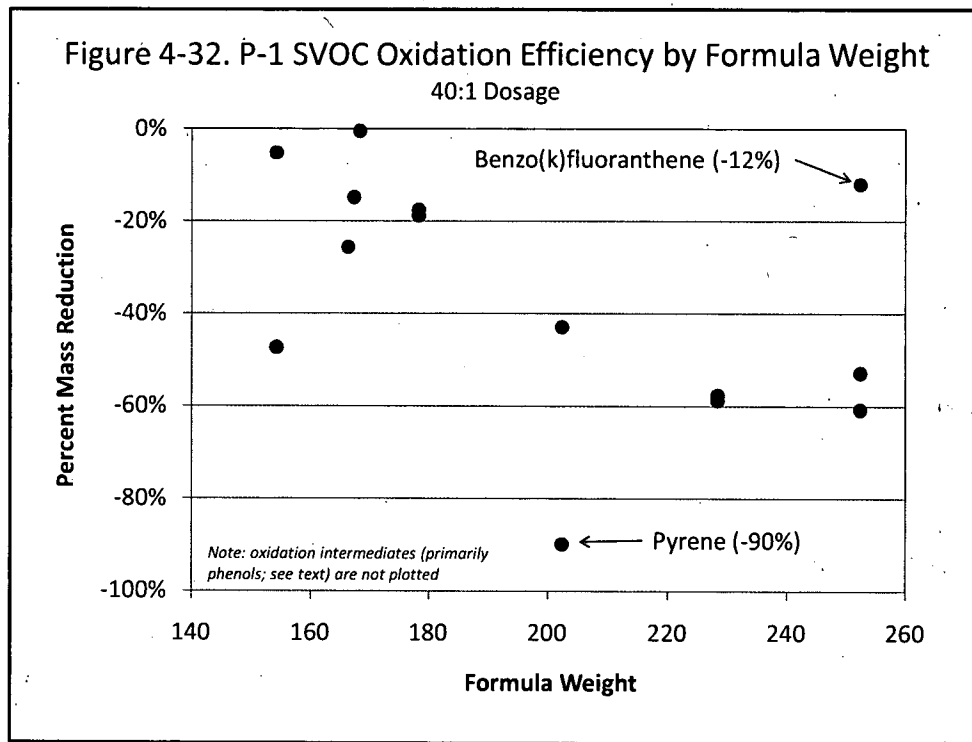


Figure 4-31. P-1 Oxidation Efficiency by Formula Weight





There is a negative relationship, with lower apparent oxidation efficiency (reflecting *higher* concentrations in the treated samples relative to the baseline concentration) at higher formula weights. The VOCs (BTEX and isopropylbenzene) and one SVOC (2,4-dimethylphenol), all with formula weights of 120.2 or less, exhibit overall reductions. Isopropylbenzene, toluene, and 2,4-dimethylphenol yielded 100% reductions; isopropylbenzene and toluene were present at relatively low concentrations (601 ug/kg or less) in the baseline, while 2,4-dimethylphenol was present at 3,400 ug/kg (consistent with the range of concentrations of other SVOCs).

Potential interpretations for the pattern exhibited in Figure 4-31 were evaluated, including VOC loss during sample handling and soil sorption. A plot of oxidation efficiency versus formula weight for the non-volatile compounds (Figure 4-32) indicates that the negative correlation remains, although is weaker than when the VOCs are included. The potential effect of soil sorption (due to the high peat content of the P-1 sample) was evaluated by plotting the organic carbon partitioning coefficient (Koc) versus formula weight (Figure 4-33). No relationship of oxidation efficiency with Koc is apparent. Thus it appears the scatter in oxidation efficiency data cannot be simply interpreted as due to either volatility or adsorption.

The following potential intermediate compounds were observed: acetone, carbon disulfide, methyl acetate, and phenol. None of these compounds have a Federal MCL. Acetone increased from non-detectable to 806 ug/L. Methyl acetate was detected only in soil and increased from non-detectable to a range of 10,300-20,500 ug/kg. Phenol was detected in the 10:1 slurry at concentrations of 388 ug/L in water and 9,000 ug/kg in soil, relative to non-detectable in the baseline and the other treated slurries. All of these compounds are potential oxidation intermediates as discussed in Sections 2.1 and 4.4.2.2. Carbon disulfide was not detected in the baseline but was detected in the treated slurries at a range of 17.2-52.6 ug/L. Carbon disulfide is not a known oxidation product, and was not detected in any of the slurries for other samples.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-3. The pH of the treated slurries ranged from 10.12 to 10.20. Due to the elevated pH and induced surface charges on the fine peat particles, the slurries tended to "fluff" and strongly maintain fine particles in solution. The suspension could not be clarified with centrifugation, and would not break until the pH was decreased into an acidic range for acid-preserved samples. As a result, obtaining a relatively low turbidity sample for metals analysis was not possible. Arsenic concentration decreased from 13,500 ug/L in the baseline to a range of 1,370-4,080 ug/L in the treated slurries, although As(III) remained detectable at 132 ug/L in the 20:1 slurry. Total chromium increased from non-detectable to a range of 389-778 ug/L in the treated slurries, although Cr(VI) remained non-detectable in the 20:1 slurry. Sulfate concentrations increased from 2,510 mg/L to 3,440 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to the persulfate reagent.

4.5. Soil Column Tests

Soil column experiments were performed as described in Section 3.3.5, to evaluate NAPL destruction as an oxidant solution is passed through a soil column, and to evaluate the potential mobility of the NAPL during oxidation. One column test was performed for each oxidant, using the SS-1 soil and a 20:1 mass ratio of oxidant: contaminant. Post-treatment samples of the soil in the column were collected and analyzed for VOCs and SVOCs. Results are tabulated in Table 4-1 and are discussed in the following Sections 4.5.1 and 4.5.2.

4.5.1. Fenton's Reagent Column

A series of photographs of the Fenton's reagent soil column over the course of the experiment is provided in Figure 4-34. The reservoir is the glass beaker on the left side of each photograph. No visible NAPL was mobilized through the column and discharged via the effluent into the reservoir. However, the filter sand became slightly stained from white to a browner color over the course of the experiment. The color of the oxidant solution also darkened, however the reddish tint of the oxidant solution and sand is primarily due to oxidized iron generated by the primary reaction that occurs during Fenton's reagent oxidation (Section 2.1, equation 1). The analytical results for the Fenton's column indicate an 83% reduction in the SVOCs and an 84% reduction in the VOCs (Table 4-1). The analytical results are overall very comparable to the slurry oxidation efficiency results, which achieved 99% oxidation of the VOCs and 69% oxidation of the SVOCs with the 20:1 slurry test. Based upon the observational results, the NAPL does not appear to be very mobile in a vertical column test with Fenton's reagent.

4.5.2. Sodium Persulfate Column

A series of photographs of the persulfate soil column over the course of the experiment is provided in Figure 4-35. The reservoir is the glass beaker on the left side of each photograph. As with the Fenton's reagent soil column, no visible NAPL was mobilized through the column and discharged via the effluent into the reservoir. However, the filter sand became slightly stained from white to a browner color over the course of the experiment. The color of the oxidant solution also darkened, and the reddish tint of the oxidant solution and soil is most likely due to oxidized iron although iron is not added as part of the catalyst for sodium persulfate. The analytical results for the persulfate column (Table 4-1) indicate an apparent 49% increase in the total VOC concentration. This apparent increase is primarily in xylene concentration in the treated soil compared to the baseline soil, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application. All other VOC concentrations are lower in the treated soil, with an average decrease of 30% when xylenes are excluded. The SVOCs yielded a 59% reduction overall. The analytical results indicate less oxidation efficiency in the column than in the 20:1 slurry, which achieved 56% oxidation of the VOCs and 69% oxidation of the SVOCs (Figure 4-20). Based upon the observational results, the NAPL also does not appear to be very mobile in a vertical column test with persulfate.

Figure 4-34. Fenton's Reagent Soil Column Photographs

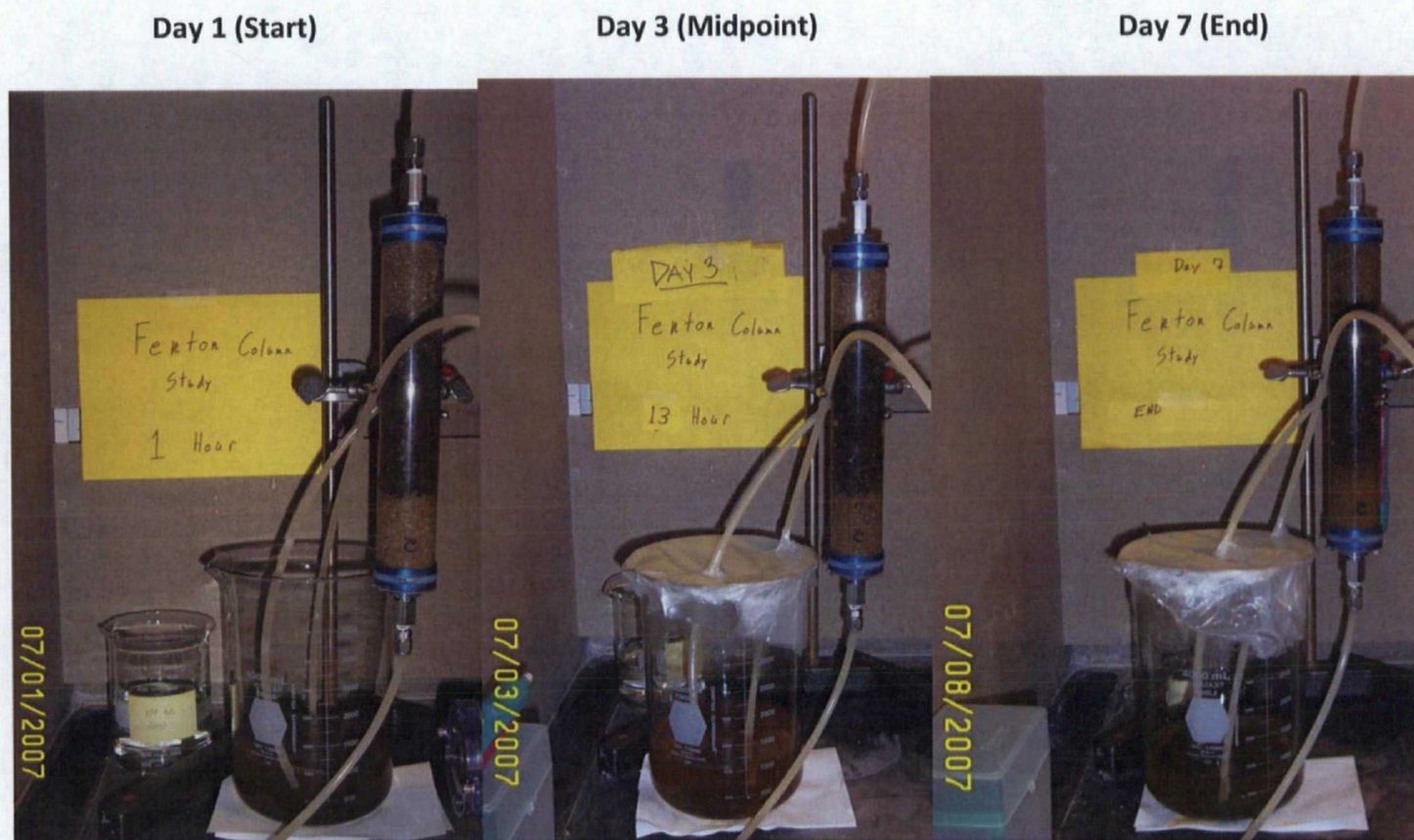
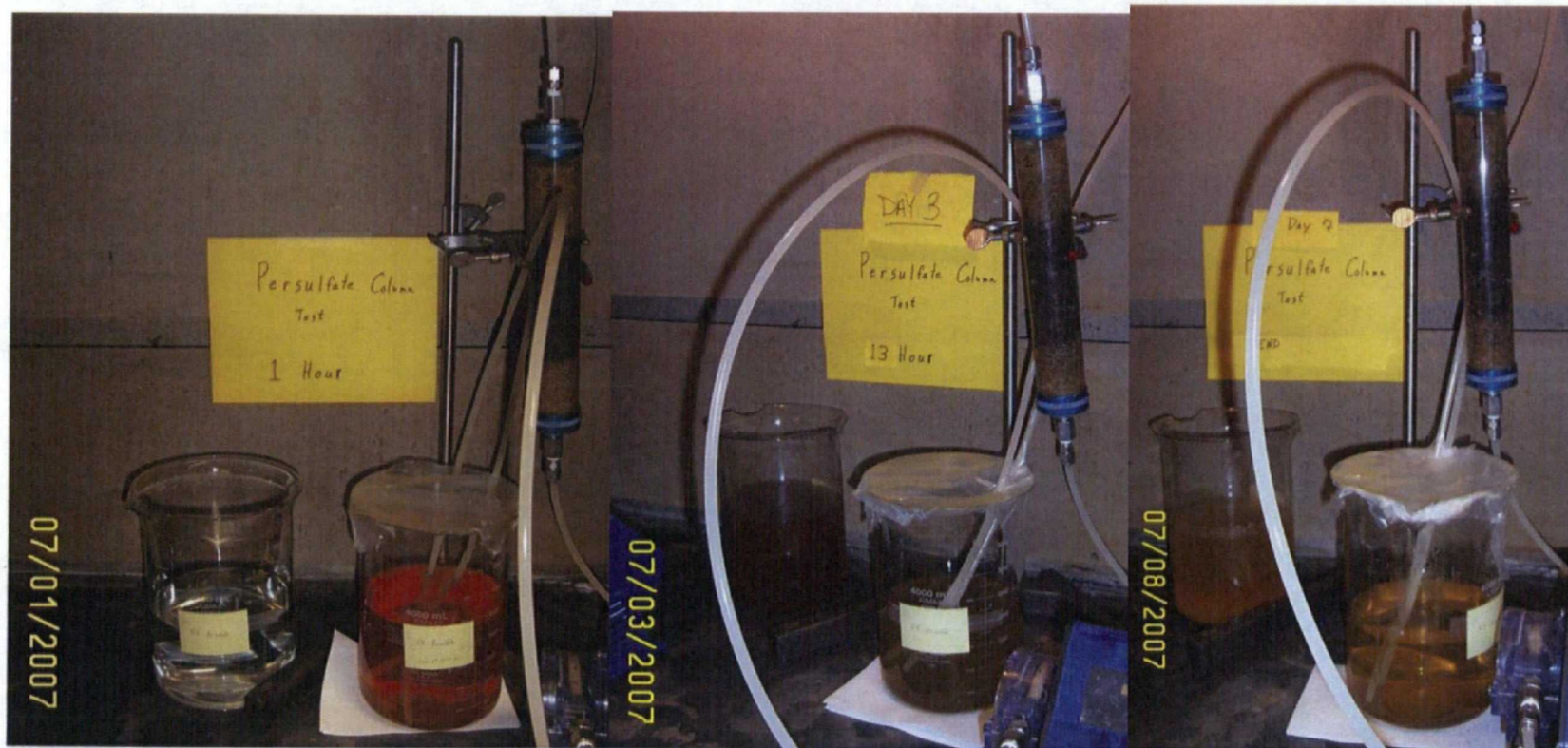


Figure 4-35. Sodium Persulfate Soil Column Photographs

Day 1 (Start)

Day 3 (Midpoint)

Day 7 (End)



4.6. Autoclave Tests

Autoclave experiments were performed as described in Section 3.3.6, in order to calculate a mass balance on the oxidation experiment and to evaluate contributions of volatilization and leaching to the overall observed volatile loss in the oxidation experiments. One test was performed for each oxidant, using the SS-1 soil and a 20:1 mass ratio of oxidant: contaminant. Volatile loss was monitored by passing offgas liberated by the oxidation reactions first through silica gel (to trap water vapor) and then carbon (to trap VOCs). Post-treatment samples of the treated soil, leachate, silica gel, and carbon were collected and analyzed for VOCs and SVOCs, and a mass balance was calculated. The laboratory analytical results are tabulated in Table 4-1, and the mass balance is calculated in Table 4-4. The results are discussed in the following Sections 4.6.1 and 4.6.2.

Traces of chlorinated VOCs including 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, tetrachloroethene, trichloroethene, methylene chloride, trichlorofluoromethane, and Freon 113, and the non-chlorinated VOCs MTBE and methylcyclohexane, were detected in the silica gel or the carbon (Table 4-1). All of the detected concentrations were low. The highest concentrations were for methylene chloride (a common laboratory contaminant) at a maximum concentration of 1,070 ug/kg; concentrations of other compounds were less than 155 ug/kg. The silica gel and carbon were virgin materials used only for these tests, and these are not known contaminants at the site. The analytes are therefore considered to most likely be spurious, trace contaminants introduced either in the bench test laboratory or the analytical laboratory, and are excluded from the mass balance calculations. Acetone and 2-butanone were also detected, but were included in the overall VOC mass balance because they are known oxidation products and were detected in other experiments.

4.6.1. Fenton's Reagent Autoclave

The Fenton's reagent autoclave test yielded approximately 99% overall oxidation. VOCs and SVOCs were transferred from the soil to the silica gel and carbon (representing volatilization) and to the leachate in measurable concentrations; however from a mass balance perspective the transferred masses were negligible relative to oxidation. Over 99.7% of the VOCs in the soil sample were oxidized, while 0.04% of the VOCs were retained on the soil, 0.10% was leached, and 0.14% was volatilized. Approximately 98.5% of the SVOCs were oxidized, while 1.5% of the SVOCs were retained on the soil. The fractions that were leached or volatilized were negligible: approximately 0.01% was leached and 0.001% was volatilized. These data indicate that overall, oxidation and destruction is the predominant mechanism accounting for loss of VOCs and SVOCs from the soil with Fenton's reagent.

4.6.2. Sodium Persulfate Autoclave

The persulfate autoclave test yielded significantly less overall oxidation than the Fenton's reagent test, however relatively little of the organic mass lost to from the soil was volatilized or leached. Over 58.9% of the VOCs in the soil sample were oxidized, while 39.7% of the VOCs were retained on the soil, 1.2%

was leached, and 0.13% was volatilized. Approximately 70.2% of the SVOCs were oxidized, while 29.8% of the SVOCs were retained on the soil. The fraction of the SVOCs that was leached or volatilized was negligible: approximately 0.02% was leached and 0.004% was volatilized. These data indicate that overall, oxidation and destruction is also the predominant mechanism accounting for loss of VOCs and SVOCs from the soil with persulfate, however overall destruction efficiency is less than for the Fenton's reagent.

Table 4-4. Autoclave Mass Balance Calculations

Fenton's Reagent Autoclave**Phase Masses**

Soil Mass (kg)	0.30
Silica Gel Mass (kg)	0.18
Carbon Mass (kg)	0.14
Leachate Volume (kg)	1.53

Phase Concentrations

	Baseline	Treated
Soil [Target VOC] (ug/kg)	662,700	297
Soil [Target SVOC] (ug/kg)	64,769,200	984,820
Silica Gel [Target VOC] (ug/kg)	0	185
Silica Gel [Target SVOC] (ug/kg)	0	592
Carbon [Target VOC] (ug/kg)	0	1,813
Carbon [Target SVOC] (ug/kg)	0	0
Leachate [Target VOC] (ug/L)	0	126
Leachate [Target SVOC] (ug/L)	0	656

Analyte Mass by Phase (milligrams)

Baseline	Soil	Silica Gel	Carbon	Leachate	Total
VOCs	198.81	0.00	0.00	0.00	198.81
SVOCs	19,430.76	0.00	0.00	0.00	19,430.76

Autoclave

VOCs	0.09	0.03	0.25	0.19	0.56
SVOCs	295.45	0.11	0.00	1.00	296.56

Mass Balance	% Retained	% Leached	% Volatilized	% Oxidized
Total VOCs	0.04%	0.10%	0.14%	99.72%
Total SVOCs	1.52%	0.01%	0.001%	98.47%

Persulfate Autoclave**Phase Masses**

Soil Mass (kg)	0.30
Silica Gel Mass (kg)	0.18
Carbon Mass (kg)	0.14
Leachate Volume (kg)	1.93

Phase Concentrations

	Baseline	Treated
Soil [Target VOC] (ug/kg)	662,700	263,200
Soil [Target SVOC] (ug/kg)	64,769,200	19,296,130
Silica Gel [Target VOC] (ug/kg)	0	269
Silica Gel [Target SVOC] (ug/kg)	0	2,263
Carbon [Target VOC] (ug/kg)	0	1,540
Carbon [Target SVOC] (ug/L)	0	1,968
Leachate [Target VOC] (ug/L)	0	1,258
Leachate [Target SVOC] (ug/L)	0	2,111

Analyte Mass by Phase (milligrams)

Baseline	Soil	Silica Gel	Carbon	Leachate	Total
VOCs	198.81	0.00	0.00	0.00	198.81
SVOCs	19,430.76	0.00	0.00	0.00	19,430.76

Autoclave

VOCs	78.96	0.05	0.21	2.43	81.65
SVOCs	5,788.84	0.42	0.27	4.07	5,793.60

Mass Balance	% Retained	% Leached	% Volatilized	% Oxidized
Total VOCs	39.72%	1.22%	0.13%	58.93%
Total SVOCs	29.79%	0.02%	0.004%	70.18%

5. Conclusions

Chemical oxidation bench tests were completed under a variety of different test methods, with different oxidants and soil types, from the Quanta Resources Superfund Site. A summary of the oxidation efficiencies for each test and soil type is presented in Table 5-1.

Table 5-1. Summary of Contaminant Mass Oxidation Efficiency

	Percent Reductions Relative to Baseline								
	Slurry Tests			Column	Autoclave	Average			
Sampe / Oxidant	10:1	20:1	40:1	20:1	20:1	20:1*			
Sample SS-1: Silty sand with visible coal tar NAPL									
Fenton's Reagent									
VOC Mass	90.3%	99.3%	99.7%	84.2%	99.7%	94.4%			
SVOC Mass	65.8%	69.2%	83.1%	82.8%	98.5%	83.5%			
Total VOC + SVOC Mass	66.0%	69.5%	83.3%	82.8%	98.5%	83.6%			
Sodium Persulfate									
VOC Mass	12.4%	58.5%	89.6%	-49.5%	58.9%	22.6%			
SVOC Mass	63.5%	69.3%	93.3%	58.5%	70.2%	66.0%			
Total VOC + SVOC Mass	63.0%	69.1%	93.2%	57.4%	70.1%	65.5%			
Sample SS-2: Silty sand with residual coal tar (no visible NAPL)									
Fenton's Reagent									
VOC Mass	86.7%	96.0%	96.2%	Column and Autoclave tests not performed for SS-2					
SVOC Mass	58.5%	81.5%	91.5%						
Total VOC + SVOC Mass	59.2%	81.8%	91.6%						
Sodium Persulfate									
VOC Mass	16.5%	55.1%	58.6%						
SVOC Mass	61.1%	63.8%	47.7%						
Total VOC + SVOC Mass	60.0%	63.6%	48.0%						
Sample P-1: Peat with residual coal tar (no visible NAPL)									
Fenton's Reagent									
VOC Mass	89.5%	93.7%	81.4%	Column and Autoclave tests not performed for P-1					
SVOC Mass	78.0%	87.5%	95.9%						
Total VOC + SVOC Mass	80.9%	89.0%	92.3%						
Sodium Persulfate									
VOC Mass	9.2%	39.1%	14.0%						
SVOC Mass	0.7%	52.3%	49.0%						
Total VOC + SVOC Mass	2.6%	32.0%	35.0%						

*Average 20:1 is the average of the slurry test result, column test result, and autoclave result, at the 20:1 dosage.

Specific objectives of the bench test outlined in Section 1, and the following sections in which each objective is specifically discussed, are:

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both (Section 5.1).
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site (Section 5.2).
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO (Section 5.3).
- Determine the relative fractions of contaminants that are oxidized, volatilized, and leached during the ISCO process (Section 5.4).
- Estimate total oxidant demand of the media (Section 5.5).
- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard may be created (Section 5.6).

Overall conclusions are presented in Section 5.7.

5.1. ISCO Applicability

The remedial objective of ISCO treatment evaluated for the purpose of this report is to destroy the mobile NAPL phase and reduce the overall VOC and SVOC mass by 80%. The results of these bench tests demonstrate:

- For NAPL source zones (represented by sample SS-1, silty sand containing visible NAPL), overall contaminant mass was reduced by approximately 66% to 99% with Fenton's reagent, and from approximately 63% to 93% with sodium persulfate, generally proportional to oxidant dosage (Table 5-1). Both oxidants achieved NAPL destruction. Thus ISCO appears to be applicable in general to NAPL-impacted soils. The relative performance of Fenton's reagent and sodium persulfate is discussed in Section 5.2.
- For residual source areas characterized by silty sand lithology (represented by sample SS-2), overall contaminant mass was reduced by 59-92% by Fenton's reagent proportional to oxidant dosage (Table 5-1). Reductions ranging from 48-64% were achieved by sodium persulfate, however the efficiency was not proportional to oxidant dosage; the highest dosage resulted in the lowest apparent reduction (Table 5-1).
- For residual source areas characterized by peat lithology (represented by sample P-1), overall contaminant mass was reduced by 81-92% by Fenton's reagent and from 3-35% by sodium persulfate, depending upon oxidant dosage. Sodium persulfate achieved a significantly lower

oxidation efficiency in the P-1 sample relative to either sodium persulfate oxidation in the SS-2 sample (silty sand with residual impact), or relative to Fenton's reagent in the P-1 or SS-2 samples. Sodium persulfate applicability is therefore more limited in peat-rich soil areas at the site relative to Fenton's reagent.

5.2. Relative Performance of Fenton's Reagent and Sodium Persulfate

Both oxidants reduced overall contaminant mass in both soil and groundwater, for both VOC and SVOC constituents of the coal tar. However, Fenton's reagent achieved greater oxidation efficiency relative to sodium persulfate in nearly every test and oxidant dosage (Table 5-1). In the most comprehensive series of tests, three different types of experiments were conducted with the 20:1 oxidant dosage for the SS-1 (NAPL-impacted) sample: slurry tests, column tests, and autoclave tests. The results show that:

- Fenton's reagent achieved 70-99% reduction among the three different types of tests, with an overall average 84% contaminant mass reduction
- Sodium persulfate achieved 57-70% reduction among the three tests, with an overall average 66% contaminant mass reduction.

Fenton's reagent also outperformed sodium persulfate in slurry tests performed for SS-2 and P-1 (with residual coal tar impacts). For comparison using the 20:1 oxidant dosages for these tests:

- Fenton's reagent achieved 82-89% contaminant mass reduction.
- Sodium persulfate achieved 32-64% contaminant mass reduction.

Sodium persulfate oxidation was relatively inefficient for the P-1 (peat) sample, achieving only 32% overall contaminant mass reduction compared to 89% for Fenton's reagent at the 20:1 dosage. Thus in terms of relative performance, Fenton's reagent yielded better oxidation efficiency at equivalent oxidant dosages than sodium persulfate.

5.3. Quantified Reduction of VOCs and SVOCs in Soil and Groundwater

The percent reductions for overall VOC and SVOC mass overall are summarized in Section 5.2 and Table 5-1. The percent reductions in the soil and groundwater concentrations for specific VOCs and SVOCs are summarized in Tables 5-2 through 5-4. Analytes included in Tables 5-2 and 5-4 are all compounds detected in the baseline samples, except potential intermediate compounds (methylphenols, phenol, and ketones). Key compounds identified in Section 1.1 are the VOCs (BTEX and isopropylbenzene) and five SVOCs (naphthalene, phenanthrene, acenaphthylene, anthracene, and pyrene).

Table 5-2. Sample SS-1 Percent Reductions in Concentration by Analyte, Phase, Oxidant, and Dosage

Analyte	Soil						Water					
	Fenton's Reagent			Sodium Persulfate			Fenton's Reagent			Sodium Persulfate		
	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
Volatile Organic Compounds												
Benzene	95.1%	99.7%	99.5%	31.7%	73.5%	94.0%	100.0%	99.9%	100.0%	98.3%	99.7%	99.9%
Toluene	96.4%	99.9%	99.8%	16.5%	54.2%	91.9%	99.9%	99.9%	100.0%	98.4%	99.9%	100.0%
Ethylbenzene	95.0%	97.5%	99.9%	12.8%	57.0%	90.3%	99.0%	99.9%	100.0%	97.4%	100.0%	100.0%
Xylene (total)	91.2%	92.6%	99.9%	1.4%	2.2%	87.7%	98.2%	99.9%	100.0%	99.3%	100.0%	100.0%
Isopropylbenzene	88.5%	96.0%	100.0%	44.2%	60.1%	93.1%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total VOCs	93.0%	95.6%	99.9%	11.1%	31.9%	89.7%	99.7%	99.9%	100.0%	98.4%	99.8%	100.0%
Semivolatile Organic Compounds												
1,1'-Biphenyl	54.8%	91.8%	90.1%	64.0%	63.0%	92.4%	59.4%	91.9%	96.1%	81.5%	87.6%	91.0%
2,4-Dimethylphenol	100.0%	100.0%	98.4%	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%
2-Methylnaphthalene	69.8%	92.7%	98.9%	57.2%	61.4%	91.5%	76.5%	98.5%	99.7%	97.0%	93.5%	98.3%
Acenaphthene	61.8%	88.2%	96.4%	67.6%	65.0%	94.5%	68.5%	92.5%	98.8%	99.6%	98.9%	99.0%
Acenaphthylene	50.0%	78.1%	45.7%	80.9%	61.3%	94.3%	97.6%	99.0%	99.4%	95.3%	99.1%	99.3%
Anthracene	61.8%	88.2%	95.8%	67.5%	67.7%	96.7%	93.8%	96.3%	99.3%	97.1%	98.1%	98.9%
Benzo(a)anthracene	44.7%	65.5%	59.8%	65.3%	62.0%	94.2%	85.0%	78.9%	95.8%	90.1%	91.1%	92.9%
Benzo(a)pyrene	37.9%	68.7%	76.8%	61.1%	61.5%	95.6%	87.5%	84.0%	98.1%	96.9%	96.9%	96.2%
Benzo(b)fluoranthene	34.0%	56.4%	36.2%	53.4%	59.1%	93.0%	82.0%	78.3%	96.5%	85.9%	84.8%	89.6%
Benzo(g,h,i)perylene	53.4%	68.7%	71.0%	74.6%	63.3%	94.4%	94.0%	89.8%	98.6%	91.7%	91.8%	93.6%
Benzo(k)fluoranthene	18.3%	56.5%	49.8%	71.9%	47.9%	94.5%	80.9%	81.1%	96.2%	86.4%	85.9%	89.7%
Carbazole	77.4%	95.1%	96.9%	87.5%	84.7%	99.5%	87.7%	99.0%	99.8%	96.6%	98.8%	99.5%
Chrysene	42.3%	65.8%	46.8%	67.1%	64.7%	94.3%	80.3%	74.9%	93.9%	81.4%	82.7%	89.1%
Dibenzo(a,h)anthracene	15.1%	58.2%	31.4%	56.9%	36.8%	91.0%	90.6%	84.4%	96.3%	90.2%	92.6%	94.0%
Dibenzofuran	53.4%	83.6%	88.9%	61.6%	59.7%	92.5%	70.3%	90.2%	96.3%	82.7%	79.1%	90.4%
Fluoranthene	45.9%	67.5%	60.0%	66.4%	64.9%	94.2%	84.6%	79.9%	95.7%	87.1%	84.4%	91.5%
Fluorene	41.8%	72.7%	74.9%	66.7%	62.0%	94.5%	57.8%	76.3%	92.7%	97.7%	89.8%	96.2%
Indeno(1,2,3-cd)pyrene	44.8%	61.3%	63.5%	64.4%	52.0%	92.5%	92.3%	87.2%	97.7%	91.5%	90.5%	92.8%
Naphthalene	92.2%	97.8%	99.8%	60.6%	72.8%	92.2%	95.1%	99.8%	100.0%	96.2%	94.5%	98.0%
Phenanthrene	54.1%	74.5%	68.7%	64.9%	63.7%	93.4%	80.4%	83.1%	95.9%	79.3%	84.1%	93.1%
Pyrene	46.4%	63.3%	61.0%	64.8%	55.6%	93.8%	87.6%	81.7%	96.8%	91.9%	94.7%	94.3%
Total SVOCs	65.8%	83.5%	83.1%	63.5%	66.0%	93.2%	92.3%	96.7%	99.2%	95.6%	94.8%	97.7%

Table 5-3. Sample SS-2 Percent Reductions in Concentration by Analyte, Phase, Oxidant, and Dosage

Analyte	Soil						Water					
	Fenton's Reagent			Sodium Persulfate			Fenton's Reagent			Sodium Persulfate		
	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
Volatile Organic Compounds												
Benzene	100.0%	89.1%	87.9%	76.5%	80.1%	72.4%	99.2%	99.3%	99.4%	97.9%	98.0%	99.6%
Toluene	93.5%	96.2%	95.7%	62.7%	68.7%	71.8%	95.7%	98.1%	98.3%	96.8%	90.8%	99.4%
Ethylbenzene	88.4%	98.1%	98.6%	46.0%	51.2%	55.0%	96.5%	99.3%	99.5%	99.4%	95.1%	100.0%
Xylene (total)	86.5%	98.3%	99.0%	47.4%	52.9%	56.7%	93.2%	98.7%	99.4%	99.6%	95.4%	100.0%
Isopropylbenzene	83.5%	100.0%	99.4%	49.2%	48.0%	50.8%	88.6%	97.7%	100.0%	100.0%	92.4%	100.0%
Total VOCs	88.3%	97.7%	98.1%	50.3%	55.3%	58.6%	96.5%	99.0%	99.3%	98.6%	95.9%	99.8%
Semivolatile Organic Compounds												
1,1'-Biphenyl	43.8%	76.4%	92.4%	55.0%	50.2%	40.4%	-94.1%	-191.0%	45.5%	47.3%	55.9%	100.0%
2,4-Dimethylphenol	100.0%	100.0%	98.1%	100.0%	100.0%	100.0%	90.6%	93.3%	97.8%	100.0%	100.0%	100.0%
2-Methylnaphthalene	63.8%	91.3%	98.0%	57.7%	65.8%	44.0%	-30.4%	-8.2%	84.1%	64.6%	90.6%	100.0%
Acenaphthene	59.2%	86.3%	96.2%	64.5%	70.2%	57.5%	-92.9%	-149.1%	66.9%	93.0%	72.5%	100.0%
Acenaphthylene	56.7%	81.9%	81.8%	65.1%	64.8%	59.9%	0.7%	18.7%	100.0%	76.7%	100.0%	100.0%
Anthracene	74.1%	84.7%	95.2%	80.9%	82.0%	83.7%	10.0%	0.8%	35.0%	100.0%	100.0%	100.0%
Benzo(a)anthracene	7.0%	51.2%	70.2%	52.3%	46.2%	37.6%	100.0%	100.0%	-60.0%	13.3%	100.0%	100.0%
Benzo(a)pyrene	8.1%	55.3%	75.1%	51.3%	51.6%	50.9%	100.0%	100.0%	0.0%	20.0%	100.0%	100.0%
Benzo(g,h,i)perylene	21.1%	61.9%	75.5%	58.3%	54.2%	43.7%	100.0%	100.0%	10.4%	100.0%	100.0%	100.0%
Benzo(k)fluoranthene	21.8%	36.1%	70.9%	47.5%	44.6%	31.2%	100.0%	100.0%	-70.5%	19.3%	100.0%	100.0%
Carbazole	80.1%	88.9%	97.2%	93.4%	96.3%	97.0%	41.1%	59.4%	85.0%	98.0%	99.6%	100.0%
Chrysene	11.8%	49.5%	64.3%	58.1%	50.8%	41.3%	100.0%	100.0%	-86.7%	13.3%	100.0%	100.0%
Dibenzofuran	51.5%	79.0%	94.0%	60.8%	64.5%	44.3%	-87.0%	-142.5%	57.9%	29.3%	57.1%	100.0%
Fluoranthene	25.4%	58.4%	75.8%	52.5%	42.3%	29.4%	74.5%	60.0%	-41.8%	57.3%	100.0%	100.0%
Fluorene	41.4%	71.0%	88.7%	66.2%	69.7%	61.5%	-201.1%	-343.7%	-21.2%	67.2%	94.9%	100.0%
Indeno(1,2,3-cd)pyrene	13.4%	49.8%	70.3%	51.9%	44.1%	32.2%	100.0%	100.0%	100.0%	-580.9%	100.0%	100.0%
Naphthalene	85.6%	98.1%	99.3%	59.3%	69.1%	44.8%	54.6%	87.3%	96.0%	68.5%	68.0%	98.5%
Phenanthrene	44.0%	70.5%	87.1%	61.2%	59.3%	44.0%	-61.6%	-128.8%	-4.1%	40.2%	94.8%	100.0%
Pyrene	17.5%	55.8%	75.5%	46.1%	31.2%	17.5%	74.7%	57.0%	-40.5%	100.0%	100.0%	100.0%
Total SVOCs	59.2%	81.7%	91.8%	61.2%	64.0%	47.9%	44.2%	68.5%	91.5%	70.1%	71.9%	98.8%

Table 5-4. Sample P-1 Percent Reductions in Concentration by Analyte, Phase, Oxidant, and Dosage

Analyte	Soil						Water					
	Fenton's Reagent			Sodium Persulfate			Fenton's Reagent			Sodium Persulfate		
	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
Volatile Organic Compounds												
Benzene	99.2%	99.7%	99.9%	74.9%	77.3%	74.4%	99.6%	99.9%	99.8%	78.3%	81.5%	84.1%
Toluene	93.1%	98.1%	100.0%	100.0%	100.0%	100.0%	99.7%	100.0%	100.0%	91.6%	91.9%	92.2%
Ethylbenzene	96.7%	99.4%	99.8%	38.1%	49.2%	45.2%	99.8%	100.0%	99.9%	93.1%	92.4%	92.7%
Xylene (total)	97.7%	99.5%	99.8%	55.9%	63.9%	58.3%	99.7%	100.0%	99.9%	92.6%	91.2%	91.1%
Isopropylbenzene	98.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total VOCs	98.1%	99.6%	99.9%	63.7%	69.4%	65.3%	99.7%	100.0%	99.9%	88.1%	88.4%	89.3%
Semivolatile Organic Compounds												
1,1'-Biphenyl	67.8%	56.7%	79.9%	-58.4%	-115.4%	-47.4%	100.0%	96.6%	98.4%	100.0%	100.0%	100.0%
2,4-Dimethylphenol	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	95.4%	96.1%	96.6%	100.0%	100.0%	100.0%
2-Methylnaphthalene	57.2%	60.2%	85.6%	-172.8%	-243.9%	-142.8%	99.6%	97.8%	99.2%	100.0%	73.8%	100.0%
Acenaphthene	81.8%	87.3%	96.9%	4.8%	-34.5%	-5.1%	99.6%	97.8%	99.4%	100.0%	100.0%	100.0%
Anthracene	74.5%	88.5%	97.1%	32.5%	-16.2%	-18.8%	100.0%	99.1%	100.0%	100.0%	100.0%	100.0%
Benzo(a)anthracene	73.5%	84.8%	94.9%	30.1%	-53.1%	-58.7%	100.0%	98.6%	99.2%	100.0%	100.0%	100.0%
Benzo(a)pyrene	72.9%	83.5%	94.4%	21.6%	-58.6%	-52.9%	100.0%	98.9%	100.0%	100.0%	100.0%	100.0%
Benzo(b)fluoranthene	69.9%	82.7%	93.9%	13.6%	-92.6%	-60.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Benzo(g,h,i)perylene	58.1%	74.3%	91.3%	-42.0%	-170.5%	-146.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Benzo(k)fluoranthene	78.1%	87.5%	95.9%	50.0%	3.9%	-11.9%	100.0%	98.5%	100.0%	100.0%	100.0%	100.0%
Carbazole	75.6%	90.1%	97.5%	27.2%	-2.2%	-14.8%	100.0%	98.3%	99.4%	100.0%	100.0%	100.0%
Chrysene	73.7%	85.0%	94.8%	28.4%	-50.9%	-57.7%	100.0%	98.4%	99.2%	100.0%	100.0%	100.0%
Dibenzo(a,h)anthracene	23.1%	60.3%	87.0%	-108.7%	-263.0%	-200.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Dibenzofuran	75.5%	78.6%	92.2%	8.4%	-34.6%	-0.5%	100.0%	95.9%	98.1%	100.0%	100.0%	100.0%
Fluoranthene	75.4%	86.8%	96.1%	34.9%	-35.4%	-42.9%	99.7%	97.9%	99.0%	100.0%	100.0%	100.0%
Fluorene	73.8%	75.0%	91.4%	-3.0%	-59.1%	-25.6%	99.7%	96.3%	98.4%	100.0%	100.0%	100.0%
Indeno(1,2,3-cd)pyrene	62.1%	77.3%	92.1%	-13.1%	-129.5%	-112.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Naphthalene	71.5%	92.9%	96.6%	-218.1%	-218.1%	-213.3%	99.6%	99.5%	99.8%	85.6%	75.3%	86.1%
Phenanthrene	78.9%	86.2%	95.9%	36.3%	-20.2%	-17.6%	99.9%	98.1%	99.1%	100.0%	71.7%	100.0%
Pyrene	75.4%	86.3%	95.8%	12.0%	-80.8%	-89.8%	99.7%	98.0%	99.0%	100.0%	100.0%	100.0%
Total SVOCs	75.3%	85.9%	95.4%	4.4%	-58.4%	-55.9%	99.6%	99.0%	99.5%	90.2%	79.2%	90.6%

For sample SS-1:

- Fenton's reagent reduced the VOC concentration in both the soil and water phases by 93-100% overall, with greater reduction at higher dosages. All VOC concentrations were reduced by at least 88.5% (isopropylbenzene in the 10:1 dosage for soil).
- Fenton's reagent reduced the SVOC concentration in soil by 66-83% overall. The lowest overall reduction (66%) was for the 10:1 dosage, while the 20:1 and 40:1 samples yielded 84% and 83%, respectively. Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 46-78%, anthracene 62-96%, naphthalene 92-100%, phenanthrene 54-75%, and pyrene 46-63%.
- The SVOCs were more susceptible to Fenton's reagent oxidation in the aqueous phase. Overall reductions ranged from 92-99%, with reductions of individual compounds as follows: acenaphthylene 98-99%, anthracene 94-99%, naphthalene 95-100%, phenanthrene 80-96%, and pyrene 82-97%.
- Sodium persulfate reduced the VOC concentration in soil by 11-90% overall, proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 32-94%, toluene 17-92%, ethylbenzene 13-90%, xylenes 1-88%, and isopropylbenzene 44-93%. In the aqueous phase, sodium persulfate reduced the VOC concentrations by 98-100% overall, with the minimum oxidation efficiency of 97% for ethylbenzene in the 10:1 dosage.
- Sodium persulfate reduced the SVOC concentration in soil by 64-93% overall, proportional to oxidant dosage. Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 81-94%, anthracene 68-97%, naphthalene 61-92%, phenanthrene 64-93%, and pyrene 56-94%.
- The SVOCs were more susceptible to persulfate oxidation in the aqueous phase. Overall reductions ranged from 95-98% in the dissolved phase, with reductions of individual compounds as follows: acenaphthylene 95-99%, anthracene 97-99%, naphthalene 95-98%, phenanthrene 79-93%, and pyrene 92-95%.

For sample SS-2:

- Fenton's reagent reduced the VOC concentration by 88-98% in soil and 99-100% in water overall, with generally greater reduction at higher dosages. All VOC concentrations were reduced by at least 84 % (isopropylbenzene in the 10:1 dosage for soil).

- Fenton's reagent reduced the SVOC concentration in soil by 59-92% overall. The lowest overall reduction (59%) was for the 10:1 dosage, while the 20:1 and 40:1 samples yielded 82% and 92%, respectively. Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 57-82%, anthracene 74-95%, naphthalene 86-99%, phenanthrene 44-87%, and pyrene 18-76%.
- The SVOC reductions from Fenton's reagent oxidation were more variable in the aqueous phase than in the soil, with some compounds showing apparent increases, most likely due to enhanced desorption. Overall reductions ranged from 44-92%, with reductions of individual compounds as follows: acenaphthylene 1-100%, anthracene 1-35%, naphthalene 55-96%, phenanthrene 4-129% increase, and pyrene 41% increase to 75% decrease.
- Sodium persulfate reduced the VOC concentration in soil by 50-59% overall, proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 72-80%, toluene 63-72%, ethylbenzene 46-55%, xylenes 47-57%, and isopropylbenzene 44-93%. In the aqueous phase, sodium persulfate reduced the VOC concentrations by 48-51% overall.
- Sodium persulfate reduced the SVOC concentration in soil by 48-64% overall, but the reductions were not proportional to oxidant dosage; the lowest reductions (48% overall) were observed at the highest dosage (40:1). Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 60-65%, anthracene 81-84%, naphthalene 45-69%, phenanthrene 44-61%, and pyrene 18-75%.
- The SVOCs were more susceptible to persulfate oxidation in the aqueous phase. Overall reductions ranged from 70-99% in the dissolved phase, proportional to oxidant dosage. Reductions of individual compounds were as follows: acenaphthylene 77-100%, anthracene 100%, naphthalene 68-99%, phenanthrene 40-100%, and pyrene 100%.

For sample P-1:

- Fenton's reagent reduced the VOC concentration by 98-100% in soil and in water overall. All VOC concentrations were reduced by at least 93% (toluene in the 10:1 dosage for soil).
- Fenton's reagent reduced the SVOC concentration in soil by 75-95% overall. The lowest overall reduction (75%) was for the 10:1 dosage, while the 20:1 and 40:1 samples yielded 86% and 95%, respectively. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene was not detected in the baseline, anthracene 75-97%, naphthalene 72-97%, phenanthrene 79-96%, and pyrene 75-96%.

- The SVOCs were more susceptible to Fenton's reagent oxidation in the aqueous phase. Overall reductions were 99-100% at all dosages. Reductions of individual compounds as follows: acenaphthylene not detected in the baseline, anthracene 99-100%, naphthalene 100%, phenanthrene 99-100%, and pyrene 99-100%.
- Sodium persulfate reduced the VOC concentration in soil by 64-69% overall. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 74-77%, toluene 100%, ethylbenzene 38-49%, xylenes 56-64%, and isopropylbenzene 100%.
- In the aqueous phase, sodium persulfate reduced the VOC concentrations by 88-89% overall. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 79-85%, toluene 92%, ethylbenzene 93%, xylenes 91-93%, and isopropylbenzene 100%.
- SVOC destruction with sodium persulfate was variable, ranging from a reduction of 4% to an apparent increase of 58%, and the differences were not proportional to oxidant dosage; the lowest reductions (4.4% overall) were observed at the lowest dosage (10:1). Oxidation of individual compounds was variable. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene not detected in the baseline, anthracene 19% increase to 33% decrease, naphthalene 213-218% increase, phenanthrene 18% increase to 36% decrease, and pyrene 90% increase to 12% decrease.
- The SVOCs were more susceptible to persulfate oxidation in the aqueous phase. Overall reductions ranged from 79-91% in the dissolved phase, but variable and not proportional to oxidant dosage. Reductions of individual compounds were as follows: acenaphthylene not detected in the baseline, anthracene 100%, naphthalene 75-86%, phenanthrene 72-100%, and pyrene 100%.

5.4. Oxidation Mass Balance

Table 4-4 summarizes the oxidation mass balance for sample SS-1 with a 20:1 dosage for each oxidant. For Fenton's reagent, the autoclave test results indicate that 99.7% of the VOCs and 98.5% of the SVOCs were oxidized. For the VOCs, approximately 0.14% were volatilized, 0.10% were leached, and 0.04% were retained on the treated soil. For the SVOCs, approximately 0.001% were volatilized, 0.01% were leached, and 1.5% were retained on the treated soil.

The persulfate results show overall lower oxidation efficiency. Approximately 58.9% of the VOCs and 70.2% of the SVOCs were oxidized. For the VOCs, approximately 1.2% were leached, 0.13% were volatilized, and 39.7% were retained on the treated soil. For the SVOCs, approximately 0.02% were leached, 0.004% were volatilized, and 29.8% were retained on the treated soil.

Thus although Fenton's reagent was a more efficient oxidant than persulfate, results for both oxidants indicate that oxidation, rather than leaching or volatilization, are the predominant mechanisms for loss of VOCs and SVOCs from the treated soils. Volatilization and leaching from the soils are negligible relative to oxidation.

5.5. Oxidant Demand

Oxidant demand is commonly expressed in terms of mass of oxidant required to satisfy the demand from a soil sample (with units of grams of oxidant per kilogram of soil or equivalent), and demand from the contaminants is typically much smaller than the demand from the soil. However with samples impacted with contaminants at relatively high concentrations such as the samples tested in this study, contaminant oxidant demand becomes much more significant. In those cases, oxidant demand is more effectively evaluated as the mass of oxidant required to achieve a specified level of contaminant reduction, and the oxidant demand is scaled as a ratio of oxidant mass to contaminant mass.

The treatment objectives evaluated are: elimination of NAPL, and 80% VOC and SVOC mass reduction. Contaminant mass reductions achieved as a function of oxidant dosage are summarized in Tables 5-1 and 5-2. Based upon physical observations for both Fenton's reagent and persulfate, no visible NAPL remained in SS-1 after a 10:1 application for either oxidant. The NAPL was apparently either destroyed, transformed by partial oxidation to a non-mobile condition, or both. Therefore, achieving a treatment goal of NAPL elimination only, with more modest overall contaminant mass reduction, can likely be achieved with a 10:1 dosage or less with either oxidant.

Overall contaminant mass reductions were generally greater for Fenton's reagent than for persulfate. For sample SS-1, a Fenton's reagent oxidant dosage of 20:1 achieved 70-99% oxidation and averaged about 84% oxidation overall. The autoclave test yielded 99% oxidation with a 20:1 dosage of Fenton's reagent. A dosage of between 10:1 and 20:1 can be expected to achieve greater than 80% oxidation (potentially up to 99% oxidation) in addition to NAPL destruction. In contrast, a persulfate dosage of 20:1 achieved 57-70% oxidation, which appears sufficient to destroy NAPL but appears unlikely to achieve a high degree of oxidation (exceeding 80%). A 93% mass reduction was achieved with a persulfate dosage of 40:1.

For sample SS-2, a 20:1 dosage of Fenton's reagent achieved 82% oxidation by mass while a 40:1 dosage increased the oxidation efficiency to 92%. In contrast, the persulfate results were more ambiguous and exhibited less overall reduction. The 20:1 persulfate dosages achieved 64% oxidation by mass, and the 40:1 dosage achieved an even less efficient oxidation of 48%.

For sample P-1, a 20:1 dosage of Fenton's reagent achieved 89% oxidation by mass while a 40:1 dosage increased the oxidation efficiency to 92%. In contrast, the persulfate results exhibited substantially less mass reduction. The 20:1 persulfate dosage achieved only 32% mass reduction, and a 40:1 dosage achieved 35% destruction. This indicates that the persulfate oxidant demand for portions of the site

represented by P-1 would be very high. The persulfate oxidant demand required to achieve significant contaminant reduction (>80%) is not likely to be achieved with a reasonable oxidant volume.

5.6. Effects of ISCO on Constituents Other Than VOCs and SVOCs

A number of other constituents were analyzed to determine how they may be affected by the ISCO reagents and treatment. Generally of most concern at the site is the impact on metals, particularly chromium and arsenic because the redox status affects mobility and toxicity of these metals. Chromium can be oxidized to the more mobile and toxic Cr(VI) valence state by chemical oxidation, while arsenic can be oxidized from the mobile As(III) valence state to the less mobile As(V) valence state. Constituents may also be present in the ISCO reagents. The concentrations of other constituents were monitored in the baseline soil and groundwater and in the soil and groundwater from the 20:1 slurries for each oxidant in order to evaluate how these other constituents may be affected. The data for the aqueous phase samples in the slurries are summarized and compared with Federal MCLs in Tables 5-5 through 5-7 and discussed below.

Total chromium and Cr(VI) were non-detectable in the baseline groundwater samples. Total chromium concentrations increased in the aqueous phase of the slurries for both oxidants. In the persulfate slurries, the total chromium concentration in the aqueous phase increased to the range of 192-778 ug/L. In the Fenton's reagent slurries, the total chromium concentration in the aqueous phase increased to the range of 21.1-4,690 ug/L. Sample SS-1 exhibited the largest total chromium increase in the aqueous phase (4,690 ug/L); total chromium in the SS-1 soil sample also exhibited a very large increase (from non-detectable in the baseline to 1,420 ug/kg), suggesting that the increased total chromium may have either been contributed by an unusual soil particle or from the reagent. The fact that large increases in soil chromium concentrations are not observed in SS-2 or P-1 suggests that the large increase is not due to the reagents. The concentration of Cr(VI) increased but not as significantly as total chromium. In the persulfate slurries, Cr(VI) ranged from non-detectable to 34 ug/L, while in the Fenton's slurries the Cr(VI) ranged from non-detectable to 71 ug/L.

Total arsenic concentration in the baseline for sample P-1 (collected from a portion of the site known to have elevated arsenic concentration) was 13,500 ug/L. However total arsenic concentrations decreased significantly in the treated samples, to 4,080 ug/L in the persulfate slurry and to 183 ug/L in the Fenton's reagent slurry. The most likely reason for the decrease is that the arsenic was oxidized from the relatively soluble As(III) valence state to the relatively immobile As(V) valence state, and with the Fenton's slurry the arsenic was likely coprecipitated with iron oxides. This interpretation is supported by the soil arsenic data and the arsenic speciation data. The soil arsenic concentration was non-detectable in the baseline soil, but increased to 43.2 ug/kg in the persulfate slurry and to 59.9 ug/kg in the Fenton's reagent slurry. The sum of the As(III) and As(V) arsenic speciation concentrations do not precisely match the total arsenic concentration (likely due to different analytical methods and preservation), however the relative proportion of As(III) to As(V) decreases from 0.39 in the baseline to 0.17 in the persulfate

slurry and 0.02 in the Fenton's slurry. This indicates less overall contribution of As(III) to the total arsenic concentration.

Total arsenic concentrations in SS-1 and SS-2 increased relative to their baseline groundwater concentrations. In SS-1, total arsenic increased from 20.6 ug/L in the baseline to 683 ug/L in the persulfate slurry and to 558 ug/L in the Fenton's slurry. In SS-2, total arsenic increased from 342 ug/L in the baseline to 767 ug/L in the persulfate slurry and to 928 ug/L in the Fenton's slurry. However as with P-1, the relative proportion of arsenic in the As(III) valence state decreased in the treated samples. In the baseline of sample SS-1, the ratio of As(III) to As(V) was 2.5 in the baseline but As(III) was non-detectable in the treated samples. In SS-2, the ratio of As(III) to As(V) was 6.9 in the baseline but As(III) was non-detectable in the persulfate slurry and the ratio was reduced to 0.006 in the Fenton's slurry.

The impact of the reagents was apparent in the total and ferrous iron concentration, sulfate concentration, and pH of the slurries. The Fenton's reagent slurries exhibited large increases in total iron concentration from the use of iron catalyst. In SS-1, total iron increased from a baseline of 1,280 ug/L to 833,000 ug/L in the slurry. In SS-2, total iron increased from 41,800 ug/L to 1,550,000 ug/L in the slurry. In P-1, total iron increased from 535,000 ug/L to 241,000 ug/L in the treated slurry. The increased iron in the Fenton's slurries will precipitate once the pH shift associated with the acidic catalyst is ameliorated. The pH of the slurries reflects the acidic catalyst for the Fenton's slurries and the base catalyst for the persulfate slurries. In SS-1, the baseline pH was 7.2, which decreased to 2.2 for the Fenton slurry and increased to 13.4 for the persulfate slurry. In SS-2 the baseline pH was 6.34, which decreased to 2.2 for the Fenton's slurry and increased to 13.1 for the persulfate slurry. In P-1 the baseline pH was 6.2, which decreased to 2.9 for the Fenton's slurry and increased to 10.2 for the persulfate slurry. Sulfate concentrations also increased, because of sulfate liberated from the persulfate as well as from the ferrous sulfate and sulfuric acid utilized in the Fenton's reagent catalyst. In SS-1, the baseline sulfate was non-detectable, and increased to 1,750 mg/L for the Fenton slurry and to 62,100 mg/L for the persulfate slurry. In SS-2 the baseline sulfate was 414 mg/L, which decreased to 4,520 mg/L for the Fenton's slurry and to 50,600 mg/L for the persulfate slurry. In P-1 the baseline sulfate concentration was 2,510 mg/L, which increased to 4,770 mg/L for the Fenton's slurry and to 3,440 mg/L for the persulfate slurry. Elemental sulfur was identified as a TIC in the SVOC analyses of the soil samples from the persulfate slurries, thus a portion of the sulfate in the persulfate slurries may have been precipitated.

Other metals with MCLs that were exceeded in the treated slurries are cadmium, selenium, and lead. Cadmium concentrations were non-detect in the SS-1 and SS-2 baseline and was 11.9 ug/L in the P-1 baseline. Cadmium remained non-detectable in the persulfate slurries, but in the Fenton slurries increased to 31.8 ug/L in SS-1, 36.0 ug/L in SS-2, and 4.4 ug/L in P-1. Selenium was non-detectable in the SS-1 and SS-2 baselines and was 48.8 ug/L in the P-1 baseline. In the persulfate slurries, selenium increased to 160 ug/L in SS-1, 164 ug/L in SS-2, and decreased to non-detectable (but with an elevated detection limit) in P-1. In the Fenton slurries, selenium increased to 93.0 ug/L in SS-1, 93.1 ug/L in SS-2, and decreased to non-detectable in P-1. Lead concentrations were non-detect in the SS-1 baseline, 3.9

Table 5-5. Impact of ISCO on Other Constituents in Sample SS-1

Analyte	Federal MCL	Baseline		Persulfate 20:1		Fenton 20:1	
		Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L or mg/Kg unless noted)							
Nitrogen, Nitrate	10	ND (<0.11)		51.6		1.4	
Nitrogen, Nitrate + Nitrite	None	ND (<0.10)		51.7		1.4	
Nitrogen, Nitrite	1	ND (<0.010)		0.11		ND (<0.010)	
Petroleum Hydrocarbons	None	5.3	1,970	ND (<0.53)	2,210	0.51	2,360
Phosphorus, Total	None	0.32		ND (<0.050)		50.8	
Sulfate	None	ND (<10)		62,100		1,750	
Total Organic Carbon	None	92.9	537,000	808	192,000	1,070	554,000
pH, standard units	None	7.20		13.42		2.19	
Metals (ug/L or mg/kg)							
Arsenic (total)	10	20.6	20.6	683	4.9	558	14.9
Arsenic (III)	None	7.5		ND (<0.56)		ND (<1.23)	
Arsenic (V)	None	3.0		658		752	
Barium	2,000	ND (<200)	89.8	ND (<2,000)	25.8	456	95.5
Cadmium	5	ND (<4.0)	1.4	ND (<40)	ND (<0.62)	31.8	ND (<0.22)
Chromium (total)	100	ND (<10)	11.7	193	2.3	4,690	1,420
Chromium (VI)	None	ND (<10)		ND (<100)		71	
Iron (total)	None	1,280	19,600	1,260	5,470	833,000	16,300
Iron (II)	None	360		110		101,000	
Lead	15	ND (<3.0)	91.1	5,600	25.5	3,070	139
Manganese	None	79.8		ND (<150)	38.9	6,270	209
Mercury	2	ND (<0.40)	0.17	0.95	0.045	ND (<0.20)	0.92
Selenium	50	ND (<10)	3.3	160	ND (<2.5)	93.0	1.6
Silver	None	ND (<10)	ND (<1.2)	ND (<100)	ND (<1.2)	12.9	ND (<0.23)
Thallium	0.5	ND (<10)	ND (<1.2)	ND (<100)	ND (<1.2)	ND (<10)	ND (<1.2)

Table 5-6. Impact of ISCO on Other Constituents in Sample SS-2

Analyte	Federal MCL	Baseline		Persulfate 20:1		Fenton 20:1	
		Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L or mg/Kg unless noted)							
Nitrogen, Nitrate	10	ND (<0.11)		4.5		2.0	
Nitrogen, Nitrate + Nitrite	None	ND (<0.10)		4.6		2.0	
Nitrogen, Nitrite	1	ND (<0.010)		0.12		ND (<0.010)	
Petroleum Hydrocarbons	None	2.5	7,270	ND (<0.62)	1,550	ND (<0.51)	1,990
Phosphorus, Total	None	0.11		4.8		ND (<0.050)	
Sulfate	None	414		50,600		4,520	
Total Organic Carbon	None	20.7	297,000	546	321,000	1,790	228,000
pH, standard units	None	6.34		13.06		2.21	
Metals (ug/L or mg/kg)							
Arsenic (total)	10	342	9.9	767	4.2	928	9.2
Arsenic (III)	None	110		ND (<0.56)		6.53	
Arsenic (V)	None	15.9		729		1,090	
Barium	2,000	236	92.2	ND (<400)	43.1	317	54.6
Cadmium	5	ND (<4.0)	ND (<0.63)	ND (<8.0)	ND (<0.72)	36.0	ND (<0.72)
Chromium (total)	100	ND (<10)	9.0	192	5.2	463	87.9
Chromium (VI)	None	ND (<10)		34		69	
Iron (total)	None	41,800	10,700	ND (<200)	9,010	1,550,000	5,910
Iron (II)	None	36,100		980		249,000	
Lead	15	3.9	116	395	64.6	2,900	80.4
Manganese	None	3,650		ND (<30)	88.5	9,070	46.5
Mercury	2	ND (<0.20)	2.1	ND (<0.40)	0.83	ND (<0.20)	1.8
Selenium	50	ND (<10)	ND (<2.5)	164	ND (<2.9)	93.1	ND (<2.9)
Silver	None	ND (<10)	ND (<1.3)	ND (<20)	ND (<1.4)	ND (<10)	ND (<1.4)
Thallium	0.5	ND (<10)	ND (<1.3)	ND (<20)	ND (<1.4)	ND (<50)	ND (<1.4)

Table 5-7. Impact of ISCO on Other Constituents in Sample P-1

Analyte	Federal MCL	Baseline		Persulfate 20:1		Fenton 20:1	
		Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L or mg/Kg unless noted)							
Nitrogen, Nitrate	10	ND (<0.11)		ND (<2.1)		0.14	
Nitrogen, Nitrate + Nitrite	None	ND (<0.10)		ND (<0.10)		0.14	
Nitrogen, Nitrite	1	ND (<0.010)		ND (<2.0)		ND (<0.010)	
Petroleum Hydrocarbons	None	27.8	309	ND (<0.53)	ND (<110)	ND (<0.53)	266
Phosphorus, Total	None	0.86		15.4		0.14	
Sulfate	None	2,510		3,440		4,770	
Total Organic Carbon	None	42.9	162,000	8,700	116,000	473	187,000
pH, standard units	None	6.23		10.17		2.89	
Metals (ug/L or mg/kg)							
Arsenic (total)	10	13,500	ND (<6.4)	4,080	43.2	183	59.9
Arsenic (III)	None	5,880		132		6.86	
Arsenic (V)	None	14,900		767		288	
Barium	2,000	ND (<200)	ND (<64)	ND (<1,000)	ND (<45)	ND (<200)	25.5
Cadmium	5	11.9	ND (<1.6)	ND (<20)	ND (<1.1)	4.4	ND (<0.56)
Chromium (total)	100	ND (<10)	24.1	778	17.9	21.1	19.8
Chromium (VI)	None	ND (<10)		ND (<1,000)		ND (<10)	
Iron (total)	None	535,000	18,500	159,000	19,100	241,000	14,900
Iron (II)	None	766,000		146,000		308,000	
Lead	15	92.4	10.3	106	9.8	28.1	8.3
Manganese	None	397		956	79.9	1,880	49.1
Mercury	2	0.93	ND (<0.054)	ND (<8.0)	ND (<0.15)	ND (<0.40)	ND (<0.075)
Selenium	50	48.8	ND (<6.4)	ND (<50)	ND (<4.5)	ND (<10)	ND (<2.2)
Silver	None	ND (<10)	ND (<3.2)	ND (<50)	ND (<2.3)	ND (<10)	ND (<1.1)
Thallium	0.5	ND (<10)	ND (<3.2)	ND (<50)	ND (<2.3)	ND (<10)	ND (<1.1)

ug/L in the SS-2 baseline and was 92.4 ug/L in the P-1 baseline. In the persulfate slurries, lead increased to 5,600 ug/L in SS-1, 395 ug/L in SS-2, and 106 ug/L in P-1. In the Fenton slurries, lead increased to 3,070 ug/L in SS-1, 2,900 ug/L in SS-2, and 28.1 ug/L in P-1.

Sulfate is a component of the catalyst in the Fenton's reagent system, and is a component of the oxidant in the persulfate system, thus increases in sulfate concentration are expected with both oxidants. The Federal Secondary WQS for sulfate is 250 mg/L. Baseline sulfate concentrations ranged from non-detectable (<10 mg/L) to 2,510 mg/L in the baseline samples. Sulfate concentrations increased in all of the slurries. With Fenton's reagent, the sulfate concentration in the 20:1 treated samples ranged from 1,070 mg/L to 4,770 mg/L. With persulfate, the sulfate concentration in the 20:1 treated samples ranged from 3,440 mg/L to 62,100 mg/L.

5.7. Overall Conclusions

- (1) Bench tests were conducted with Fenton's reagent and base-catalyzed sodium persulfate to determine if in-situ chemical oxidation may be a viable technology for the Quanta Resources Superfund Site. Three samples were tested. Two samples represent silty sand soil impacted with residual coal tar constituents, one of which also contained visible NAPL. The third sample represented a peat soil impacted with residual coal tar constituents.
- (2) Soil pH buffering tests indicate that both acidic pH conditions (favorable for Fenton's reagent) and alkaline pH conditions (favorable for persulfate) can be readily achieved with all three soil types tested.
- (3) Known intermediate oxidation products were observed. Those products included ketones (acetone, 2-butanone), phenols (phenol and methylphenol), and methyl acetate. None of these compounds has a Federal MCL.
- (4) ISCO affected the aqueous concentrations of several constituents other than VOCs and SVOCs. Sulfate and iron included as components of the reagents utilized increased, while pH decreased for the Fenton's slurries and increased for the persulfate slurries. Several metals were either mobilized from the soil or may have been present in the catalyst components, including arsenic, chromium, cadmium, selenium, and lead. There was relatively little oxidation of chromium to the more mobile and toxic Cr(VI) valence state. Total arsenic concentrations increased in the silty sand tests (which do not have elevated baseline arsenic concentrations), but in contrast to chromium, almost all of the arsenic was oxidized from the relatively mobile As(III) valence state to the less mobile As(V) valence state. In the peat sample (with elevated baseline arsenic), arsenic concentrations decreased in the treated slurries.
- (5) Based upon visual observations during the slurry tests, NAPL was either destroyed or was transformed to a non-mobile condition by both oxidants at dosages with ratios of oxidant to contaminant mass of 10:1 or less.

- (6) Oxidation efficiency generally was negatively correlated with formula weight for both oxidants. Compounds with lower formula weights were oxidized more efficiently than compounds with higher formula weight.
- (7) Slurry tests, soil column tests, and autoclave tests all indicate that Fenton's reagent is a more efficient oxidant than persulfate for the Quanta soils. Fenton's reagent yielded 59-99% oxidation of total contaminant mass depending upon oxidant dosage, whereas persulfate yielded 3-93% oxidation.
- (8) Persulfate was relatively ineffective with the peat-rich soil sample, achieving a maximum of 35% contaminant mass oxidation. Fenton's reagent achieved a maximum of 93% oxidation with the same oxidant dosage.
- (9) Autoclave tests were performed with the silty sand sample containing visible NAPL to assess the contribution of volatilization and leaching to overall contaminant loss from the soil. Tests with both oxidants indicate that oxidation is the predominant mechanism. Fenton's reagent was most effective, and achieved 99.7% oxidation of the VOCs and 98.5% oxidation of the SVOCs, and only about 0.3% of the total contaminant mass was transferred to the leachate or volatilized. Persulfate achieved 58.9% VOC oxidation and 70.2% SVOC oxidation. Approximately 1.3% of the VOCs were leached or volatilized, and approximately 0.02% of the SVOCs were leached or volatilized. The balance of the VOCs and SVOCs were retained on the treated soils.
- (10) For Fenton's reagent, ratios of oxidant : contaminant mass between 10:1 and 20:1 resulted in loss of visible NAPL and 60-99% contaminant mass destruction, with an average 84% destruction for three different types of tests utilizing 20:1 dosages. For persulfate, oxidant : contaminant mass ratios between 10:1 and 20:1 also resulted in loss of visible NAPL and 57-93% oxidation, excluding the peat-rich sample. The peat-rich sample yielded a maximum of 35% oxidation with a 40:1 mass ratio of persulfate to contaminant mass.
- (11) Fenton's reagent achieved better oxidation efficiencies in all three soils types tested.
- (12) Fenton's reagent and persulfate are likely to be relatively equal in terms of ease of implementation in the silty-sand portions of the site. This is because both oxidants require modification of the groundwater chemistry that can be readily achieved, and because both oxidants require mixing and injection of liquid reagents. In the peat-rich portions of the site, persulfate will most likely be more difficult to implement due to dispersion of fine-grained soil materials under high-pH conditions, which resulted in significant "fluffing" of the peat matrix. This may significantly affect the ability to inject the liquid reagents.
- (13) Fenton's reagent is likely to be less costly than persulfate to achieve the same magnitude of treatment. Lower dosages were required for Fenton's reagent relative to persulfate, and hydrogen peroxide is a significantly less costly oxidant than persulfate.

6. References

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Appendix C
Detailed Cost Evaluation

TABLE C-1

Comparison of Total Cost of Remedial Alternatives

Draft Feasibility Study, Quanta Resources Site, Edgewater, New Jersey

	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
	Containment	Containment, Excavation, and In Situ Solidification/ Stabilization	In Situ Solidification/ Stabilization	In Situ Solidification/ Stabilization and Other In Situ Treatment	Excavation
Total Capital Cost	\$25,570,000	\$50,508,750	\$34,810,000	\$75,484,060	\$93,780,333
Soil	\$14,350,000	\$39,218,750	\$32,060,000	\$69,204,060	\$91,030,333
Groundwater	\$2,650,000	\$2,750,000	\$2,750,000	\$2,750,000	\$2,750,000
NAPL	\$8,570,000	\$8,540,000	\$0	\$3,530,000	\$0
Total O&M Cost	\$14,214,600	\$14,295,600	\$5,439,600	\$8,139,600	\$5,898,600
Soil	\$1,077,000	\$1,158,000	\$1,002,000	\$1,002,000	\$1,461,000
Groundwater	\$4,437,600	\$4,437,600	\$4,437,600	\$4,437,600	\$4,437,600
NAPL	\$8,700,000	\$8,700,000	\$0	\$2,700,000	\$0
Total Periodic Cost	\$1,498,932	\$1,401,352	\$1,221,473	\$1,251,470	\$997,605
Soil	\$1,162,608	\$1,065,028	\$1,056,473	\$1,056,470	\$832,605
Groundwater	\$165,000	\$165,000	\$165,000	\$165,000	\$165,000
NAPL	\$171,324	\$171,324	\$0	\$30,000	\$0
Total Present Value	\$31,850,000	\$56,810,000	\$37,380,000	\$79,980,000	\$96,510,000
Soil	\$14,990,000	\$39,880,000	\$32,650,000	\$69,800,000	\$91,780,000
Groundwater	\$4,630,000	\$4,730,000	\$4,730,000	\$4,730,000	\$4,730,000
NAPL	\$12,230,000	\$12,200,000	\$0	\$5,450,000	\$0

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternatives. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the actual project costs. Rev. Feb. 10, 2009.

Alternative 2: Containment - DRAFT

COST ESTIMATE SUMMARY

Site: Quanta Resources Site-Edgewater, New Jersey	Description:
Phase: Preliminary Draft Feasibility Study Report	- Tar boils at the ground surface throughout the site and shallow NAPL areas would be capped. NAPL would be collected via 14 recovery wells located in NZ-1, and NZ-5 and two trenches located in NZ-2 near the Hudson River. Institutional controls would be established to document and limit use of areas where contamination remains in place.
Base Year: 2008	- A funnel and gate system or permeable reactive barrier would be installed to prevent potential NAPL migration to the Hudson River.
Date: 2/10/2008	- The existing High Concentration Arsenic Area (HCAA) liner would be maintained, and the other arsenic-contaminated soils >336 ppm would be capped. Institutional controls would be established to document and limit use of areas with contamination remaining in place.
	- Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
	- The basement in the 115 River Road building would be converted to a crawl space with ventilation. Institutional controls would be established and maintained to prevent vapor intrusion into new buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and Former Lever Brother properties, as needed.
	- A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established. SHEET PILE AND DISPOSAL OF SEDIMENT ARE NOT INCLUDED IN THIS ESTIMATE.

CAPITAL COSTS

SOIL	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
General Site Work							
	Mobilization/Demobilization	5%		\$	8,071,517	\$ 403,576	Calculate as 5% of capital cost
	Subcontractor General Conditions	10%		\$	8,071,517	\$ 807,152	Calculate as 10% of capital cost
	SUBTOTAL					\$ 1,210,728	
Site Establishment							
	Survey	100	DY	\$	1,500	\$ 150,000	CCI Historical
	Fencing	6,000	LF	\$	15	\$ 90,000	CCI Historical
	Trailer Installation & Setup	1	EA	\$	3,000	\$ 3,000	CH2M Est.
	Support Area Establishment and Site Offices	24	MO	\$	4,300	\$ 103,200	CH2M Est.
	SUBTOTAL					\$ 346,200	Tie-downs, stairs; power Includes shed, utilities, lavatories
Institutional Controls (Quanta, 115 River Road, Edgewater, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW, Former Lever Bros)							
	Deed Notices (1 for each property)	9	LS	\$	25,000	\$ 225,000	CH2M Est.
	SUBTOTAL					\$ 225,000	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Clearing & Vegetation/Debris Disposal							
Site Clearing & Disposal (Quanta Property)							
	Temporary erosion controls (silt fencing)	2,624	LF	\$	1.28	\$ 3,369	MEANS 31.25.13.10.1100
	Clear and Grub Heavy Brush & Trees (includes chipper)	3	AC	\$	8,203	\$ 24,610	MEANS 31.11.10.10.0260
	Tank pad concrete removal & sizing to less than 2 feet	5,645	TON	\$	128	\$ 720,634	MEANS 02.41.13.17.5500
	Asphalt removal	3,969	SY	\$	3.76	\$ 14,925	Source 3
	Subsurface piping abandonment	1	LS	\$	250,000	\$ 250,000	
	Offsite disposal of cleared materials, concrete (including transportation to < 50 miles)	3,528	CY	\$	205	\$ 723,316	MEANS 33-19-7270
	Asphalt Disposal	331	CY	\$	25	\$ 8,275	Source 3
	Dust suppression	20	DY	\$	820	\$ 16,400	MEANS 31.23.23.18.4500
	SUBTOTAL					\$ 1,761,529	Concurrent site activities/dust control
Site Clearing & Disposal (Block 93, 115 River Road)							
	Temporary erosion controls (silt fencing)	2,100	LF	\$	1.28	\$ 2,696	MEANS 31.25.13.10.1100
	Asphalt removal	12,578	SY	\$	3.76	\$ 47,294	Source 3
	Asphalt Disposal	1,048	CY	\$	25	\$ 26,200	Source 3
	Dust suppression	5	DY	\$	820	\$ 4,100	MEANS 31.23.23.18.4500
	SUBTOTAL					\$ 80,290	Concurrent site activities/dust control
Site Clearing & Disposal (Edgewater and Lever Brothers)							
	Temporary erosion controls (silt fencing)	2,000	LF	\$	1.28	\$ 2,568	MEANS 31.25.13.10.1100
	Concrete removal & sizing to less than 2'	6,438	TON	\$	118	\$ 759,684	MEANS 02.41.13.17.5500
	Asphalt removal	6,305	SY	\$	3.76	\$ 23,707	Source 3
	Offsite disposal of concrete (including transportation < 50 miles)	3,577	CY	\$	130	\$ 464,967	MEANS 33-19-7270
	Asphalt Disposal	525	CY	\$	25	\$ 13,125	Source 3
	Dust suppression	30	DY	\$	820	\$ 24,600	MEANS 31.23.23.18.4500
	Dig Permits & Utility Markout	10	DAY	\$	3,000	\$ 30,000	Source 3
	SUBTOTAL					\$ 1,318,651	Concurrent site activities/dust control
Capping							
New Engineered Impermeable Cap (Block 93 North, Block 93 Central, Block 93 South)							
	Rough site grading	17,045	SY	\$	5.15	\$ 87,708	MEANS 17-03-0101
	Fine grading	17,045	SY	\$	1.42	\$ 24,233	MEANS 17-03-0101
	Gravel Base, 6 inches	2,841	CY	\$	53	\$ 151,914	MEANS 32.11.23.23.1511
	Dust suppression	30	DY	\$	820	\$ 24,600	MEANS 31.23.23.18.4500
	Storm water control (3' x 3' culverts, rip-rap)	6	EA	\$	11,638	\$ 69,826	Source 4
	Asphalt stabilized binder course, 2" thick	17,045	SY	\$	23	\$ 390,143	MEANS 32.12.16.13.0120
	Asphalt wear course, 2" thick	17,045	SY	\$	23	\$ 399,390	MEANS 32.12.16.13.0380
	Install Asphalt Curb/Berm on Perimeter	4,300	LF	\$	11	\$ 47,472	MEANS 32.16.19.10.0150
	SUBTOTAL					\$ 1,195,287	Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above Assume no fill needed for grading Assume no fill needed for grading Concurrent site activities/dust control Included 2 storm water control systems per capped property
Upgrade Cap (115 River Road)							
	Asphalt removal	10,349	SY	\$	3.76	\$ 38,911	Source 3
	Rough site grading	10,349	SY	\$	5.15	\$ 53,250	MEANS 17-03-0101
	Fine grading	10,349	SY	\$	1.42	\$ 14,712	MEANS 17-03-0101
	Gravel Base, 6 inches	1,725	CY	\$	53	\$ 92,231	MEANS 32.11.23.23.1511
	Storm water control (3' x 3' culverts, rip-rap)	2	EA	\$	11,638	\$ 23,275	Source 4
	Asphalt stabilized binder course, 2" thick	10,349	SY	\$	23	\$ 236,871	MEANS 32.12.16.13.0120
	Asphalt wear course, 2" thick	10,349	SY	\$	23	\$ 242,485	MEANS 32.12.16.13.0380
	Install Asphalt Curb/Berm on Perimeter	2,100	LF	\$	11	\$ 23,184	MEANS 32.16.19.10.0150
	Asphalt disposal (recycled)	862	CY	\$	25	\$ 21,560	Source 3
	SUBTOTAL					\$ 746,478	3" thick asphalt
New Cap (115 River Road Property - Basement Area)							
	Clear & disposal of basement materials (equipment, etc.)	16,722	SF	\$	0.43	\$ 7,239	MEANS 02.41.19.19.0300
	Abandon/Demo Basement Facility Trench Drains (trenching, concrete, grating)	1,700	LF	\$	68	\$ 115,600	MEANS 22.14.26.19.6650
	Disposal of Basement Demo Material	1	LS	\$	10,000	\$ 10,000	Estimator Judgement
	HDPE Liner, 40 mil thick	1,858	SY	\$	15	\$ 28,669	ECHOS 33.08.0572
	2 feet sub-base clean fill layer for basement	1,239	CY	\$	53	\$ 66,237	MEANS 17-03-0423
	Install Concrete Floor 2 feet thick	1,239	CY	\$	206	\$ 255,374	MEANS 03.31.05.35.0300
	Insulation	16,722	SF	\$	2	\$ 33,444	MEANS 03.31.05.70.4300
	SUBTOTAL					\$ 516,563	Normal weight concrete and placement, 2 feet thick pad

Alternative 2: Containment - DRAFT

COST ESTIMATE SUMMARY

New Vegetative Cap (Quanta Property)										Silt fence around Quanta property included under engineered cap
Rough grading	24,774	SY	\$	5.15	\$	127,478	MEANS 17-03-0101			
Fine grading	24,774	SY	\$	1.42	\$	35,221	MEANS 17-03-0101			
Protective layer, 12" compacted soil subgrade	8,258	CY	\$	18	\$	146,188	MEANS 17-03-0423			
HDPE Liner, 40 mil thick	24,774	SY	\$	15	\$	382,266	ECHOS 33.08.0572			
Drainage layer, 6" granular soil (assume gravel)	4,129	CY	\$	53	\$	220,797	MEANS 32.11.23.23.1511			
Grade, Place Geotextile filter fabric	24,774	SY	\$	2.00	\$	49,548	Source 3			
Vegetative layer, 18" soil	12,387	CY	\$	18	\$	219,280	MEANS 17-03-0423			
Top soil, 6"	4,129	CY	\$	30	\$	123,871	MEANS 31.05.13.10.0800			
Dust suppression	45	DY	\$	820	\$	36,901	MEANS 31.23.23.18.4500	Concurrent site activities/dust control		
Hydroseed	222,968	SF	\$	0.07	\$	15,608	Source 3			
Watering	223	MSF	\$	55.84	\$	12,452	MEANS 32.01.09.26.4900	Based on 111,484-SF: 1" of water per 1,000 sf, 4		
SUBTOTAL					\$	1,369,611		-watering events (.25-in per event)		
Compliance Monitoring and Health & Safety										
Environmental Controls	1	LS	\$	12,772	\$	12,772	Source 4			
Install Decon Shed for workers (Mobilization & Demobilization)	1	LS	\$	500.00	\$	500	Source 3			
Decon Shed	9	MO	\$	1,043	\$	9,383	Source 4			
Air Monitoring	90	DY	\$	718	\$	64,575	Source 4 + CH2M,H&S			
PPE Provisions for Workers (Initial)	20	EA	\$	252	\$	5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor		
PPE Provisions for Workers (Worker-Days)	3,960	EA	\$	106	\$	419,640	Source 4 + CH2M H&S			
SUBTOTAL					\$	511,908				
CAPITAL SUBTOTAL - Soil					\$	9,282,244				
Contingency	25%				\$	2,320,561	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11			
SUBTOTAL					\$	11,602,805				
Project Management	5%				\$	580,140	USEPA 2000, p. 5-13, >\$10M			
Remedial Design	6%				\$	696,168	USEPA 2000, p. 5-13, >\$10M			
Construction Management	6%				\$	696,168	USEPA 2000, p. 5-13, >\$10M			
SUBTOTAL					\$	1,972,477				
Contractor Fees										
ODC & Subs	5%		\$	11,602,805	\$	580,140		Calculate as 5% of capital cost		
Labor	10%	max	\$	1,972,477	\$	197,248		Calculate as 10% of labor cost		
SUBTOTAL					\$	777,388				
TOTAL CAPITAL COST - Soil					\$	14,350,000				

GROUNDWATER

General										
Mobilization/Demobilization	5%			\$	1,464,000	\$	73,200			Calculate as 5% of capital cost
Subcontractor General Conditions	10%			\$	1,464,000	\$	146,400			Calculate as 10% of capital cost
SUBTOTAL						\$	219,600			
Site Preparation										
Erosion Control	1	LS		\$	20,000	\$	20,000			
Permitting	1	LS		\$	150,000	\$	150,000			
Survey (pre and post installation)	2	EA		\$	2,500	\$	5,000			
Staging Pad	1	LS		\$	10,000	\$	10,000			
Rental and operation of generator	1	MO		\$	17,050	\$	17,050			
Rental of frac tank	1	MO		\$	500	\$	500			\$150/dy rent + \$400/dy fuel = \$550/dy
Portadam® Barriers - Setup, tear-down, and one month rental	1,200	LF		\$	100	\$	120,000			
Portadam® Barriers - Additional rental	2	WK		\$	15,600	\$	31,200			
Cut-Off Timber Piles Allowance	1	LS		\$	150,000	\$	150,000			
SUBTOTAL						\$	503,750			
Excavate 2' of Impacted Sediment										
Pump out area within Portadams®	30	DY		\$	1,275	\$	38,250	Source 3		750 GPM Godwin Dri-Prime 6" Model CD150M
Pump fuel and oil	1,500	GAL		\$	4	\$	6,000	Source 3		3.1 GPH Diesel Fuel x 24 hrs/day x 20 days
Excavate 2' sediment from dewatered area	11,000	CY		\$	25	\$	275,000	Source 3		Assumed area 160' x 950'
Transportation of material back to staging pad	11,000	CY		\$	4	\$	44,000	Source 3		
SUBTOTAL						\$	363,250			
Install RCM Mat & Armor Layer										
Organoclay RCM material	120	ROLL		\$	3,000	\$	360,000	Source 3		20% extra for overlap - 1,500 ft2/roll x \$2.00/ft2
Install organoclay RCM	150,000	SF		\$	1	\$	75,000	Source 3		
12" sand armor layer (material only)	6,000	CY		\$	20	\$	120,000	Source 3		
Install 12" sand armor layer	6,000	CY		\$	7	\$	42,000	Source 3		
SUBTOTAL						\$	597,000			
CAPITAL SUBTOTAL - Groundwater						\$	1,683,600			
Contingency	25%					\$	420,900	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11		
SUBTOTAL						\$	2,104,500			
Project Management	5%					\$	105,225	USEPA 2000, p. 5-13, \$2M - \$10M		
Remedial Design	8%					\$	168,360	USEPA 2000, p. 5-13, \$2M - \$10M		
Construction Management	6%					\$	126,270	USEPA 2000, p. 5-13, \$2M - \$10M		
SUBTOTAL						\$	399,855			
Contractor Fees										
ODC & Subs	5%			\$	2,104,500	\$	105,225			Calculate as 5% of capital cost
Labor	10%	max		\$	399,855	\$	39,986			Calculate as 10% of labor cost
SUBTOTAL						\$	145,211			
TOTAL CAPITAL COST - GROUND WATER						\$	2,650,000			

NAPL

General									
Mobilization/Demobilization	5%		\$	4,736,651	\$	236,833			Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$	4,736,651	\$	473,665			Calculate as 10% of capital cost
SUBTOTAL					\$	710,498			
<u>Tunnel & Gate System (Organoclay Reactive Material)</u>									
Site Preparation									
Erosion Control	1	LS	\$	10,000	\$	10,000			
Permitting	1	LS	\$	150,000	\$	150,000			
Survey (pre and post installation)	2	EA	\$	2,500	\$	5,000			
SUBTOTAL					\$	165,000			
Sheetpile and Reactive Gate Installation									
Trench Excavation	250	CY	\$	5.00	\$	1,250	CH2M HILL Est.		
Boulder Removal/Disposal	100	CY	\$	80.00	\$	8,000	CH2M HILL Est.		
Organoclay Reactive Material	90	LF	\$	1,004	\$	90,360	Vendor's Estimate		1.5' thick, 20 feet deep
On-site stabilization of excavated trench spoils with Portland Cement	4,280	CY	\$	40	\$	171,200	CH2M HILL Est.		
Sealed Sheet piling (Waterloo Barrier)	26,250	SF	\$	68	\$	1,785,000	Source 3		750 LF X 35' Depth for sheet pile
Backfill with stabilized material	1,979	TON	\$	12	\$	23,744	CH2M HILL Est.		
Disposal of stabilized material	3,957	TON	\$	130	\$	514,453	MEANS 33-19-7270		
Dust suppression	30	DY	\$	820	\$	24,600	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
SUBTOTAL					\$	2,618,607			

Alternative 2: Containment - DRAFT

COST ESTIMATE SUMMARY

NAPL Recovery Trenches

Preconstruction Investigations						
Slurry compatibility test	1	LS	\$	25,000	\$	25,000
Pumping Test	1	LS	\$	75,000	\$	75,000 CH2M Est.
Pilot Field Test	1	LS	\$	100,000	\$	100,000 CH2M Est., assumed design of test is included in design line item (@ 8%)
Utility Markout / Locating Service	3	LS	\$	3,000	\$	9,000
SUBTOTAL					\$	209,000
Recovery Trench Installation						Assumed asphalt, concrete removal, site clearing is covered under soil remediation costing
On-Site Slurry Mixing Plant	1	LS	\$	144,000	\$	144,000 Estimators Judgment
Biopolymer Slurry (trench stabilization)	155,000	GAL	\$	0.06	\$	9,300 Based on total trench volume, ECHOS
Trenching, for Recovery System	767	CY	\$	15	\$	11,505 MEANS
Trench Backfill / Placement with Tremie Pipe	763	CY	\$	1.83	\$	1,396 MEANS, Backfill with gravel
Gravel, dumped and delivered	763	CY	\$	35	\$	26,361 MEANS
Geosynthetic Clay Liner	230	SF	\$	3.02	\$	696 Assume Claymax 200R or equivalent, Source 3
Backfill with clean soil to grade	4	CY	\$	19	\$	76
Precast Concrete Sump (4'x4'x4') w/Aluminum manhole for well access	2	EA	\$	4,000	\$	8,000 Estimators Judgment
Trench development	1	LS	\$	10,350	\$	10,350 Estimators Judgment
24" SS Extraction Wells w/ Sumps	62	LF	\$	250	\$	15,500 Installed to a depth of 31 ft bgs
Product Recovery Pumps	2	EA	\$	4,000	\$	8,000 Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					\$	235,185
Install Equipment & Utilities for NAPL Collection/Handling						
Utility Trenching	1,153	CY	\$	7.04	\$	8,122 4 ft Deep, Includes Piping & Power Distribution, Source 3
Electrical Conduit	3,040	LF	\$	1.68	\$	5,099 Assume power & controls wiring run in separate conduit, MEANS 260-533.10
Backfill to grade	1,153	CY	\$	19	\$	22,017 Source 3
NAPL Recovery Piping (Double walled)	1,075	LF	\$	50	\$	53,750 Assume 2" piping, material of construction
Freeze Protection for Recovery Piping	1,075	LF	\$	3	\$	3,225 Heat trace
Control System & Wiring (includes panels)	1	EA	\$	25,000	\$	25,000 Includes remote access & autodialer
Control Wiring	2	EA	\$	800	\$	1,600
Power Supply to the Site	1	LS	\$	16,000	\$	16,000 Includes distribution gear, disconnects to tie-in to central utility, Estimators Judgment
Power Wiring, #10 Insulated Strand Wire	3,040	LF	\$	0.59	\$	1,794
Electrical Disconnect, weatherhead, and installation of wiring	2	EA	\$	5,000	\$	10,000 Pumps are 1 HP, 230V or 460V, 3 Phase, Estimators Judgment
Concrete Pad	1	LS	\$	25,000	\$	25,000 CH2M Est.
Plumbing, Fire Suppression	1	LS	\$	10,000	\$	10,000 CH2M Est.
Utility Connections	1	LS	\$	10,000	\$	10,000 CH2M Est.
Permits	1	LS	\$	1,500	\$	1,500 CH2M Est.
Storage Tanks, 200 gallon	1	EA	\$	4,970	\$	4,970 HDPE Tanks with ports for inlet / vent / level / outlet, Baliff Enterprises price
Spare Product Recovery Pumps	2	EA	\$	4,000	\$	8,000 Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					\$	206,076
Offsite Treatment / Disposal						
On-Site Waste Management - Soil	1,920	CY	\$	7.00	\$	13,442 Staging, dewatering
On-Site Waste Management - Water	80,383	GAL	\$	1.00	\$	80,383 Engineer's Estimate
Off-site Disposal of Contaminated Water	80,383	GAL	\$	1.00	\$	80,383 Dewatering of Excavated Soil & Trench Dewatering & Decon Water
Off-site Disposal of Soil	1,920	CY	\$	205	\$	393,668 Include soils from Trench Waste & Recovery Wells, assume sent to HW landfill
Off-site Disposal of Municipal Waste	300	CY	\$	130	\$	39,000
SUBTOTAL					\$	606,876
System Startup						
	1	LS	\$	50,000	\$	50,000 Estimators Judgment
Compliance Monitoring and Health & Safety						
Environmental Controls	1	LS	\$	11,577	\$	11,577 Source 4
Analytical Requirements for Disposal	1,920	CY	\$	2.60	\$	4,993 Source 3
Install Decon Shed for workers	1	LS	\$	1,043	\$	1,043 Source 4
Decon Shed	4	MO	\$	1,400	\$	5,600 Source 4
Air Monitoring	16	DY	\$	718	\$	11,480 Source 4 + CH2M H&S
PPE Provisions for Workers (Initial)	20	EA	\$	252	\$	5,038 Source 4
PPE Provisions for Workers (Worker-Days)	1,760	EA	\$	21	\$	37,301 Source 4 + CH2M H&S
SUBTOTAL					\$	77,031
NAPL Recovery Wells						
Preconstruction Investigations						
Pumping Test	1	LS	\$	75,000	\$	75,000 CH2M Est.
Utility Markout / Locating Service	3	LS	\$	3,000	\$	9,000 Source 3
SUBTOTAL					\$	84,000
Sentinel Well Installation						
Soil Borings, 2" Diameter	105	LF	\$	22	\$	2,310 Air rotary rig and crew, wells are 15' deep, 7 wells
2-inch SS Well Screen	63	LF	\$	25	\$	1,576 Well is screened from 4' bgs to bottom of well
2-inch SS Well Riser	42	LF	\$	15	\$	622 4' of well riser
Sand / Bentonite Materials	7	EA	\$	400	\$	2,800 Source 3
Backfill borings, pea gravel	6	CY	\$	35	\$	207 Source 3
Well development	7	EA	\$	1,600	\$	11,200 Source 3
Flush mount completion	7	EA	\$	250	\$	1,750
SUBTOTAL					\$	20,465
Recovery Well Installation						
Soil Borings, 24" Diameter	210	LF	\$	300	\$	63,000 Air rotary rig and crew, wells are 15' deep, 14 wells
8-inch SS Well Casing	210	LF	\$	197	\$	41,280 Casing along full length of well (15' deep), 14 wells, ECHOS
8-inch SS Well Screen	154	LF	\$	197	\$	30,338 Well is screened from 4' bgs to bottom of well, 14 wells
8-inch SS Well Riser	56	LF	\$	197	\$	11,032 4' of well riser, 14 wells
Sand / Bentonite Materials	14	EA	\$	400	\$	5,600 Source 3
Backfill borings, pea gravel	13	CY	\$	35	\$	449 Source 3
Well development	14	EA	\$	1,600	\$	22,400 Source 3
Product Recovery Pumps	7	EA	\$	4,000	\$	28,000 Positive displacement piston pump, 1HP motor, 0-7 GPM, vendor budgetary
Roadboxes (for sump / well access)	7	EA	\$	2,500	\$	17,500 Assume asphalt cap under soil remediation costing ties into roadboxes
SUBTOTAL					\$	219,599
Install Equipment & Utilities for NAPL Collection/Handling						
Utility Trenching	133	CY	\$	11	\$	1,467 4 ft Deep, Includes Piping & Power Distribution, Source 3
Electrical Conduit	600	LF	\$	8.00	\$	4,800 ECHOS 20.02.0610
Backfill to grade	160	CY	\$	19	\$	3,054 Use 1.2X compaction factor
Control Wiring	7	EA	\$	500	\$	3,500
Power Supply to the Site	1	LS	\$	16,000	\$	16,000 Includes gear/disconnects to tie-in to central utility, Estimators Judgment
Power Wiring, #10 Insulated Strand Wire	600	LF	\$	0.59	\$	354 Source 3
Electrical Disconnect, weatherhead, and installation of wiring	7	EA	\$	5,000	\$	35,000 Pumps are 1 HP, 230V or 460V, 3 Phase, Estimators Judgment
Spare Product Recovery Pumps	2	EA	\$	4,000	\$	8,000 Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					\$	72,175
Offsite Treatment / Disposal						
On-Site Waste Management - Soil	146	CY	\$	7.00	\$	1,024 Transfer to drums for disposal
Off-site Disposal of Soil	146	CY	\$	205	\$	29,998 Include soils from well and trench installation, assume sent to HW landfill
Off-site Disposal of Municipal Waste	240	CY	\$	130	\$	31,200 Assume 2 rollofs per month
Off-site Disposal of NAPL (well development)	5	GAL	\$	2.00	\$	10 Source 3
SUBTOTAL					\$	62,233
System Startup						
	1	LS	\$	50,000	\$	50,000 Estimators Judgment

Alternative 2: Containment - DRAFT

COST ESTIMATE SUMMARY

Compliance Monitoring and Health & Safety									
Environmental Controls	1	LS	\$	11,577	\$	11,577	Source 4		
Analytical Requirements for Disposal	146	CY	\$	2.60	\$	380	Source 3	Based on total materials to be disposed	
Install Decon Shed for workers	1	LS	\$	1,043	\$	1,043	Source 4		
Decon Shed	4	MO	\$	1,043	\$	4,170	Source 4		
Air Monitoring	16	DY	\$	718	\$	11,480	Source 4 + CH2M H&S		
PPE Provisions for Workers (Initial)	15	EA	\$	252	\$	3,778	Source 4		
PPE Provisions for Workers (Worker Days)	1,320	EA	\$	21	\$	27,976	Source 4 + CH2M H&S		
SUBTOTAL					\$	60,404			
CAPITAL SUBTOTAL - NAPL					\$	5,447,149			
Contingency	25%				\$	1,361,787	10% Scope + 15% Bid		
SUBTOTAL					\$	6,808,936			
Project Management	5%				\$	340,447	USEPA 2000, p. 5-13, \$2M - \$10M		
Remedial Design	8%				\$	544,715	USEPA 2000, p. 5-13, \$2M - \$10M		
Construction Management	6%				\$	408,536	USEPA 2000, p. 5-13, \$2M - \$10M		
SUBTOTAL					\$	1,293,698			
Contractor Fees									
ODC & Subs	5%		\$	6,808,936	\$	340,447	Calculate as 5% of capital cost		
Labor	10%	max	\$	1,293,698	\$	129,370	Calculate as 10% of labor cost		
SUBTOTAL					\$	469,817			
TOTAL CAPITAL COST - NAPL					\$	8,570,000			

SOIL

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Cap Maintenance					
Cap Repair	1	LS	\$ 18,158	\$ 18,158	Assumes 1% of area requires repair annually, cap costs are based on repaving and maintaining the soil cap at Quanta
Cap Inspection and Repair Report	1	LS	\$ 2,000	\$ 2,000	
Fan System Maintenance (115 River Road)	8	HR	\$ 80	\$ 640	
SUBTOTAL				\$ 20,798	
Contingency	25%			\$ 5,199	10% Scope + 15% Bid
SUBTOTAL				\$ 25,997	
Project Management	5%			\$ 1,300	
Technical Support	25%			\$ 6,499	
SUBTOTAL				\$ 7,799	
Contractor Fees					
ODC & Subs	5%		\$ 25,997	\$ 1,300	Calculate as 5% of capital cost
Labor	10%	max	\$ 7,799	\$ 780	Calculate as 10% of labor cost
SUBTOTAL				\$ 2,080	
TOTAL ANNUAL O&M COST - Soil (Year 1 to 30)				\$ 35,900	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
2 Year Biennial Certification	2	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	4	1	LS	\$ 4,613	\$ 4,613	
5 year Review	5	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	6	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	8	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	10	1	LS	\$ 4,613	\$ 4,613	
5 year Review	10	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	12	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	14	1	LS	\$ 4,613	\$ 4,613	
5 year Review	15	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road	15	1	LS	\$ 5,000	\$ 5,000	
2 Year Biennial Certification	16	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	18	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	20	1	LS	\$ 4,613	\$ 4,613	
5 year Review	20	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	22	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	24	1	LS	\$ 4,613	\$ 4,613	
5 year Review	25	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	26	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	28	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	30	1	LS	\$ 4,613	\$ 4,613	
5 year Review	30	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road	30	1	LS	\$ 5,000	\$ 5,000	
Asphalt Cap Replacement	30	1	LS	\$ 993,413	\$ 993,413	Assume complete replacement of 30% of cap after 30 years
					\$ 1,162,608	
TOTAL ANNUAL PERIODIC COST - Soil				\$ 1,160,000		

Alternative 2: Containment - DRAFT

COST ESTIMATE SUMMARY

PRESENT VALUE ANALYSIS		Discount Rate = 7.0%		Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.		
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 14,350,000	\$ 14,350,000	1.00	\$ 14,350,000	
ANNUAL O&M COST - Cap	1 to 30	\$ 1,077,000	\$ 35,900	12.41	\$ 445,485	
PERIODIC COST	1	\$ -	\$ -	0.93	\$ -	
PERIODIC COST	2	\$ 4,613	\$ 4,613	0.87	\$ 4,029	
PERIODIC COST	3	\$ -	\$ -	0.82	\$ -	
PERIODIC COST	4	\$ 4,613	\$ 4,613	0.76	\$ 3,519	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	6	\$ 4,613	\$ 4,613	0.67	\$ 3,074	
PERIODIC COST	8	\$ 4,613	\$ 4,613	0.58	\$ 2,685	
PERIODIC COST	10	\$ 19,613	\$ 19,613	0.51	\$ 9,970	
PERIODIC COST	12	\$ 4,613	\$ 4,613	0.44	\$ 2,048	
PERIODIC COST	14	\$ 4,613	\$ 4,613	0.39	\$ 1,789	
PERIODIC COST	15	\$ 20,000	\$ 20,000	0.36	\$ 7,249	
PERIODIC COST	16	\$ 4,613	\$ 4,613	0.34	\$ 1,563	
PERIODIC COST	18	\$ 4,613	\$ 4,613	0.30	\$ 1,365	
PERIODIC COST	20	\$ 19,613	\$ 19,613	0.26	\$ 5,068	
PERIODIC COST	22	\$ 4,613	\$ 4,613	0.23	\$ 1,041	
PERIODIC COST	24	\$ 4,613	\$ 4,613	0.20	\$ 909	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	26	\$ 4,613	\$ 4,613	0.17	\$ 794	
PERIODIC COST	28	\$ 4,613	\$ 4,613	0.15	\$ 694	
PERIODIC COST	30	\$ 1,018,026	\$ 1,018,026	0.13	\$ 133,735	
					\$ 14,988,476	
TOTAL PRESENT VALUE FOR SOIL					\$ 14,990,000	

GROUNDWATER

OPERATIONS AND MAINTENANCE COST

Inspection of Subaqueous Reactive Barrier (SRB)						
Sampling of barrier during low tide	1	LS	\$	15,000	\$ 15,000	Excavator onsite for 5 days--expose 5% of barrier every 5 years
Barrier replacement	1	LS	\$	149,250	\$ 149,250	25% of barrier every 5 years
SUBTOTAL					\$ 164,250	
Allowance for Misc. Items	20%				\$ 32,850	
SUBTOTAL					\$ 197,100	
Contingency	25%				\$ 49,275	10% Scope + 15% Bid
SUBTOTAL					\$ 246,375	
Project Management	5%				\$ 12,319	
Technical Support	25%				\$ 61,594	
					\$ 73,913	
Contractor Fees						
ODC & Subs	5%		\$	246,375	\$ 12,319	Calculate as 5% of capital cost
Labor	10%	max	\$	73,913	\$ 7,391	Calculate as 10% of labor cost
SUBTOTAL					\$ 19,710	
TOTAL FOR SRB O&M					\$ 340,000	
Groundwater Monitoring						
Groundwater Samples	16	EA	\$	645	\$ 10,320	Pesticides, TAL Metals
QC Samples	5	EA	\$	645	\$ 3,225	Historical Pricing
Groundwater Sampling, Level D						
Labor	150	HR	\$	80	\$ 12,000	CH2M Est. - 3 persons for 5 days
Equipment - meters	1	LS	\$	500	\$ 500	CH2M Est.
Consumables	1	LS	\$	200	\$ 200	CH2M Est.
Data Validation	24	HR	\$	80	\$ 1,920	CH2M Est.
Reporting	50	HR	\$	80	\$ 4,000	CH2M Est.
SUBTOTAL					\$ 32,165	
Allowance for Misc. Items	20%				\$ 6,433	
SUBTOTAL					\$ 38,598	
Contingency	25%				\$ 9,650	10% Scope + 15% Bid
SUBTOTAL					\$ 48,248	
Project Management	5%				\$ 2,412	
Technical Support	25%				\$ 12,062	
					\$ 14,474	
Contractor Fees						
ODC & Subs	5%		\$	48,248	\$ 2,412	Calculate as 5% of capital cost
Labor	10%	max	\$	14,474	\$ 1,447	Calculate as 10% of labor cost
SUBTOTAL					\$ 3,860	
TOTAL FOR GROUNDWATER SAMPLING EVENT					\$ 66,600	
TOTAL ANNUAL O&M COST Year 0 to 2					\$ 266,400	Quarterly for 2 years
TOTAL ANNUAL O&M COST Year 3 to 30					\$ 66,600	Annually
TOTAL ANNUAL O&M COST Year 5, 10, 15, 20, 25, 30					\$ 340,000	Cap maintenance

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 year Review	5	1	LS	\$ 15,000	\$ 15,000	
5 year Review	10	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	10	1	LS	\$ 25,000	\$ 25,000	
5 year Review	15	1	LS	\$ 15,000	\$ 15,000	
5 year Review	20	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	20	1	LS	\$ 25,000	\$ 25,000	
5 year Review	25	1	LS	\$ 15,000	\$ 15,000	
5 year Review	30	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	30	1	LS	\$ 25,000	\$ 25,000	
					\$ 165,000	
TOTAL ANNUAL PERIODIC COST					\$ 170,000	

Alternative 2: Containment - DRAFT

COST ESTIMATE SUMMARY

PRESENT VALUE ANALYSIS		Discount Rate = 7.0%				
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 2,650,000	\$ 2,650,000	1.00	\$ 2,650,000	
ANNUAL O&M COST (Year 0-2)	0 to 2	\$ 532,800	\$ 266,400	1.81	\$ 481,656	
ANNUAL O&M COST (Year 3-30)	3 to 30	\$ 1,864,800	\$ 66,600	10.60	\$ 706,028	
ANNUAL O&M COST (Year 5)	5	\$ 340,000	\$ 340,000	0.71	\$ 242,415	
ANNUAL O&M COST (Year 10)	10	\$ 340,000	\$ 340,000	0.51	\$ 172,839	
ANNUAL O&M COST (Year 15)	15	\$ 340,000	\$ 340,000	0.36	\$ 123,232	
ANNUAL O&M COST (Year 20)	20	\$ 340,000	\$ 340,000	0.26	\$ 87,862	
ANNUAL O&M COST (Year 25)	25	\$ 340,000	\$ 340,000	0.18	\$ 62,645	
ANNUAL O&M COST (Year 30)	30	\$ 340,000	\$ 340,000	0.13	\$ 44,665	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 40,000	\$ 40,000	0.51	\$ 20,334	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 40,000	\$ 40,000	0.26	\$ 10,337	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 40,000	\$ 40,000	0.13	\$ 5,255	
					\$ 4,626,163	
TOTAL PRESENT VALUE FOR GROUNDWATER					\$ 4,630,000	

NAPL

Funnel Gate Organoclay Reactive Material							
Sampling of Reactive Material	1	LS	\$	10,000	\$	10,000	3 locations 6 samples, 20-ft deep
SUBTOTAL					\$	10,000	
NAPL Recovery							
Electricity - Pump Operation (1.5 HP pump)	7	EA	\$	1,618	\$	11,329	MEANS 33-42-0102
Misc. Electrical Site Usage	12	MO	\$	3,660	\$	43,924	MEANS 33-42-0106
Routine Operations, Maintenance, Monitoring	600	Hr	\$	80	\$	48,000	Assumes part time operator performs duties for NAPL system (5 days/month)
Parts Replacement / Consumables	1	LS	\$	5,000	\$	5,000	
O&M Project Management	1	LS	\$	7,200	\$	7,200	15% of O&M
Electricity	12	MO	\$	1,500	\$	18,000	MEANS 33-42-0106
Reporting	1	LS	\$	20,000	\$	20,000	CH2M Est.
Pumping & Transport of NAPL (Vac Truck)	1,000	GAL	\$	1.00	\$	1,000	Assume each truck 1000 gallons
Off-site Disposal of NAPL	2,000	GAL	\$	2.00	\$	4,000	
SUBTOTAL					\$	158,453	
SUBTOTAL ANNUAL O&M					\$	168,453	
Contingency	25%				\$	42,113	10% Scope + 15% Bid
SUBTOTAL					\$	210,566	
Project Management					\$	10,528	
Technical Support	5%				\$	52,641	
	25%				\$	63,170	
Contractor Fees							
ODC & Subs	5%		\$	210,566	\$	10,528	Calculate as 5% of capital cost
Labor	10%	max	\$	63,170	\$	6,317	Calculate as 10% of labor cost
SUBTOTAL					\$	16,845	
TOTAL ANNUAL O&M COST (Year 0 to 30)					\$	290,000	

PERIODIC COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 year Review	5	1	LS \$	15,000 \$	15,000
5 year Review	10	1	LS \$	15,000 \$	15,000
Replacement of Reactive Material	10	1	LS \$	27,108 \$	27,108 30% replaced
5 year Review	15	1	LS \$	15,000 \$	15,000
5 year Review	20	1	LS \$	15,000 \$	15,000
Replacement of Reactive Material	20	1	LS \$	27,108 \$	27,108 30% replaced
5 year Review	25	1	LS \$	15,000 \$	15,000
5 year Review	30	1	LS \$	15,000 \$	15,000
Replacement of Reactive Material	30	1	LS \$	27,108 \$	27,108 30% replaced
					\$ 171,324
TOTAL ANNUAL PERIODIC COST					\$ 171,000

PRESENT VALUE ANALYSIS		Discount Rate = 7.0%				
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 8,570,000	\$ 8,570,000	1.0	\$ 8,570,000	
ANNUAL O&M COST	1 to 30	\$ 8,700,000	\$ 290,000	12.41	\$ 3,598,622	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 42,108	\$ 42,108	0.51	\$ 21,406	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 42,108	\$ 42,108	0.26	\$ 10,882	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 42,108	\$ 42,108	0.13	\$ 5,532	
					\$ 12,225,336	
TOTAL PRESENT VALUE OF NAPL					\$ 12,230,000	

Total Present Value for Alternative 2 \$31,850,000

SOURCE INFORMATION	
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).	
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)	
2b. R.S. Means Company. 2007. 26th Edition.	
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.	
3. Historical CH2M HILL project cost information	
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)	

Alternative 3: Containment, Excavation, and In Situ Solidificaton/Stabilization - DRAFT

COST ESTIMATE SUMMARY

Site: Quanta Resources Site-Edgewater, New Jersey	Description: - Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft for offsite disposal. NAPL would be collected via 14 recovery wells located in NZ-1 and NZ-5 and two recovery trenches located in NZ-2 near the Hudson River. Institutional controls would be established to document and limit use of areas where contamination remains in place.
Phase: Preliminary Draft Feasibility Study Report	-A funnel and gate system or permeable reactive barrier would be installed to prevent potential NAPL migration to the Hudson River.
Base Year: 2008	-Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic cap would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with contamination remaining in place.
Date: 2/10/2008	-Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
	-The basements in the 115 River Road building would be converted to crawl spaces with active ventilation. Institutional controls would be established and maintained to control new construction and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and former Lever Brother properties, as needed.
	-A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established. SHEET PILE AND DISPOSAL OF SEDIMENT ARE NOT INCLUDED IN THIS ESTIMATE.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Mobilization/Demobilization	5%		\$ 22,055,464	\$ 1,102,773		Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$ 22,055,464	\$ 2,205,546		Calculate as 10% of capital cost
SUBTOTAL				\$ 3,308,320		
Site Establishment						
Survey	100	DY	\$ 1,500	\$ 150,000	CCI Historical	
Fencing	6000	LF	\$ 15	\$ 90,000	CCI Historical	
Trailer Installation & Setup	1	EA	\$ 3,000	\$ 3,000	CH2M Est.	Tie-downs, stairs, power
Support Area Establishment and Site Offices	24	MO	\$ 4,300	\$ 103,200	CH2M Est.	Includes shed, utilities, lavatories
SUBTOTAL				\$ 346,200		
Institutional Controls (Quanta, 115 River Road, Edgewater, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW, Former Lever Bros)						
Deed Notices (1 for each property)	9	LS	\$ 25,000	\$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
SUBTOTAL				\$ 225,000		
Clearing & Vegetation/Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	\$ 1.28	\$ 3,369	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and Grub Heavy Brush & Trees (includes chipper)	3	AC	\$ 8,203	\$ 24,610	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, assumes 20% of Quanta requires clearing
Tank pad concrete removal & sizing to less than 2 feet	5,645	TON	\$ 128	\$ 720,634	MEANS 02.41.13.17.5500	Concrete demolition, on grade slab, assumes 2' thick concrete pads on 20% of Quanta site, 15% of pads are removed
Asphalt removal	3,969	SY	\$ 3.76	\$ 14,925	Source 3	Assumes 3" thick asphalt to be cleared from 15% of Quanta
Subsurface piping abandonment	1	LS	\$ 250,000	\$ 250,000		Engineer's Estimate
Offsite disposal of cleared materials, concrete (including transportation to < 50 miles)	3,528	CY	\$ 205	\$ 723,316	MEANS 33-19-7270	Assumes HW landfill: Concrete pads + Clearing at 30 CY/AC
Asphalt Disposal	331	CY	\$ 25	\$ 8,275	Source 3	
Dust suppression	20	DY	\$ 820	\$ 16,400	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				\$ 1,761,529		
Site Clearing & Disposal (Block 93, 115 River Road)						
Temporary erosion controls (silt fencing)	2,100	LF	\$ 1.28	\$ 2,696	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	12,578	SY	\$ 3.76	\$ 47,294	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 and 115 River Road
Asphalt Disposal	1,048	CY	\$ 25	\$ 26,200	Source 3	
Dust suppression	5	DY	\$ 820	\$ 4,100	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				\$ 80,290		
Site Clearing & Disposal (Edgewater - Arsenic Area)						
Temporary erosion controls (silt fencing)	1,500	LF	\$ 1.28	\$ 1,926	MEANS 31.25.13.10.1100	Surrounding property boundary
Concrete removal & sizing to less than 2'	6,061	TON	\$ 118	\$ 715,159	MEANS 02.41.13.17.5500	Concrete demolition of access ramp, assumes 2-ft of concrete
Asphalt removal	6,361	SY	\$ 3.76	\$ 23,918	Source 3	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Offsite disposal of concrete (including transportation to < 50 miles)	3,367	CY	\$ 130	\$ 437,715	MEANS 33-19-7270	Assumes non-HW landfill
Asphalt Disposal	530	CY	\$ 25	\$ 13,250	Source 3	
Dust suppression	40	DY	\$ 820	\$ 32,801	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	10	DY	\$ 3,000	\$ 30,000	Source 3	
Excavation, stockpile and backfill of 10-ft of soils above the existing arsenic liner	21,204	CY	\$ 35	\$ 750,473	MEANS 17-03-0276	Assumes material will be replaced following the completion of arsenic stabilization
Temporary Access	1	allow	\$ 65,000	\$ 65,000		
SUBTOTAL				\$ 2,070,241		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	500	LF	\$ 1.28	\$ 642	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	764	SY	\$ 3.76	\$ 2,872	Source 3	Assumes 3" thick asphalt to be cleared
Asphalt Disposal	64	CY	\$ 25	\$ 1,600	Source 3	
Dust suppression	7	DY	\$ 820	\$ 5,740	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	1	DY	\$ 3,000	\$ 3,000	Source 3	
SUBTOTAL				\$ 13,854		
Excavation, Backfilling, & Soil Disposal						
Excavation of Tar Boils, Soils Containing Tars						
Dig Permits & Utility Markout	3	DAY	\$ 3,000	\$ 9,000	Source 3	
Excavation of Contaminated soil (from tar boils & containing soft, plastic, or hard tars)	31,243	CY	\$ 30	\$ 927,923	MEANS 17-03-0276	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	37,492	CY	\$ 18	\$ 663,698	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	12	DY	\$ 820	\$ 9,840	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
On-site stabilization of excavated contaminated soils with Portland Cement	61,862	TON	\$ 35	\$ 2,165,154	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 Tons/CY
Disposal of stabilized contaminated soil removed (from tar boils & containing soft, plastic, or hard tars), pad material- Non-Haz Waste	35,570	CY	\$ 130	\$ 4,624,150	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in weight from add'l material, 2.0 Tons/CY)
Confirmation Sampling	62	EA	\$ 200	\$ 12,400	CH2M Est.	
Data Validation	40	HR	\$ 90	\$ 3,600	CH2M Est.	
Shoring around buildings	2,263	LF	\$ 62	\$ 1,122,448		Assumes sheet pile will be driven 8 feet bgs
SUBTOTAL				\$ 9,538,213		

Alternative 3: Containment, Excavation, and In Situ Solidificaton/Stabilization - DRAFT

COST ESTIMATE SUMMARY

In-Situ Stabilization (Arsenic Materials > 336 mg/kg) (Quanta and Block 93 North)									
Set-up Fee	1	LS	\$	40,000	\$	40,000	CH2M HILL Est.		
Jet Grout around Utilities	300	LF	\$	35	\$	10,500	CH2M HILL Est.		
Reagent at 5% Additive - Ferrous Sulfate	22,441	CY	\$	22	\$	486,970	Source 3	39276	
Reagent at 15% Additive - Cement	22,441	CY	\$	30	\$	666,498	Source 3		
In-Situ Mixing	22,441	CY	\$	30	\$	673,230	Vendor		Assume mixing with 8-ft mixing auger
Tear-Down/Decon	1	LS	\$	2,500	\$	2,500	Source 3		
SUBTOTAL					\$	1,879,697			
In-Situ Stabilization (Arsenic Materials > 336 mg/kg) (Edgewater)									
Set-up Fee	1	LS	\$	40,000	\$	40,000	CH2M HILL Est.		
Jet Grout around Utilities	1,200	LF	\$	35	\$	42,000	CH2M HILL Est.		
Reagent at 5% Additive - Ferrous Sulfate	16,835	CY	\$	21.7	\$	365,320	Source 3		
Reagent at 15% Additive - Cement	16,835	CY	\$	30	\$	500,000	Source 3		
In-Situ Mixing	16,835	CY	\$	30	\$	505,050	Vendor		Assume mixing with 8-ft mixing auger
Tear-Down/Decon	1	LS	\$	2,500	\$	2,500	Source 3		
SUBTOTAL					\$	1,454,869			
Capping									
New Engineered Impermeable Cap (Block 93 North, Block 93 Central, Block 93 South)									
Rough site grading	17,045	SY	\$	5.15	\$	87,708	MEANS 17-03-0101		Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above
Fine grading	17,045	SY	\$	1.42	\$	24,233	MEANS 17-03-0101		Assume no fill needed for grading
Gravel Base, 6 inches	2,841	CY	\$	53.47	\$	151,914	MEANS 32.11.23.23.1511		Assume no fill needed for grading
Dust suppression	30	DY	\$	820	\$	24,600	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
Storm water control (3' x 3' culverts, rip-rap)	6	EA	\$	7,680	\$	46,079	Source 4		Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	17,045	SY	\$	22.89	\$	390,143	MEANS 32.12.16.13.0120		
Asphalt wear course, 2" thick	17,045	SY	\$	23.43	\$	399,390	MEANS 32.12.16.13.0380		
Install Asphalt Curb/Berm on Perimeter	4,300	LF	\$	11.04	\$	47,472	MEANS 32.16.19.10.0150		
SUBTOTAL					\$	1,171,540			
Replacement of Access Ramp and Parking Lots (Edgewater)									
Backfilling and compaction of excavated material	21,204	CY	\$	18	\$	375,358	MEANS 17-03-0423		Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above
Rough site grading	8,275	SY	\$	5.15	\$	42,580	MEANS 17-03-0101		Assumes 1.2x excavated material required for compaction
Fine grading	8,275	SY	\$	1.42	\$	11,764	MEANS 17-03-0101		Assume no fill needed for grading
Gravel Base, 6 inches	1,379	CY	\$	53	\$	73,741	MEANS 32.11.23.23.1511		Assume no fill needed for grading
Dust suppression	60	DY	\$	820	\$	49,201	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
Storm water control (3' x 3' culverts, rip-rap)	2	EA	\$	11,638	\$	23,275	Source 4		Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	8,275	SY	\$	23	\$	189,407	MEANS 32.12.16.13.0120		
Asphalt wear course, 2" thick	8,275	SY	\$	23	\$	193,896	MEANS 32.12.16.13.0380		
Install Asphalt Curb/Berm on Perimeter	2,500	LF	\$	11	\$	27,600	MEANS 32.16.19.10.0150		
SUBTOTAL					\$	986,821			
Upgrade Cap (115 River Road)									
Asphalt removal	10,349	SY	\$	3.76	\$	38,911	Source 3		3" thick asphalt
Rough site grading	10,349	SY	\$	5.15	\$	53,250	MEANS 17-03-0101		Assume no fill needed for grading
Fine grading	10,349	SY	\$	1.42	\$	14,712	MEANS 17-03-0101		Assume no fill needed for grading
Gravel Base, 6 inches	1,725	CY	\$	53	\$	92,231	MEANS 32.11.23.23.1511		
Storm water control (3' x 3' culverts, rip-rap)	2	EA	\$	11,638	\$	23,275	Source 4		Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	10,349	SY	\$	23	\$	236,871	MEANS 32.12.16.13.0120		
Asphalt wear course, 2" thick	10,349	SY	\$	23	\$	242,485	MEANS 32.12.16.13.0380		
Install Asphalt Curb/Berm on Perimeter	2,100	LF	\$	11	\$	23,184	MEANS 32.16.19.10.0150		
Asphalt disposal (recycled)	862	CY	\$	25	\$	21,560	Source 3		3" thick asphalt
SUBTOTAL					\$	746,479			
New Cap (115 River Road Property - Basement Area)									
Clear & disposal of basement materials (equipment, etc.)	16,722	SF	\$	0.43	\$	7,239	MEANS 02.41.19.19.0300		Assumption: 1 ton of mtrl & equip/250sf (15.81' x 15.81')
Abandon/Demo Basement Facility Trench Drains (trenching, concrete, grating)	1,700	LF	\$	68	\$	115,600	MEANS 22.14.26.19.6650		
Disposal of Basement Demo Material	1	LS	\$	10,000	\$	10,000	Estimator Judgement		
HDPE Liner, 40 mil thick	1,858	SY	\$	15	\$	28,669	ECHOS 33.08.0572		
2 feet sub-base clean fill layer for basement	1,239	CY	\$	53	\$	66,237			
Install Concrete Floor 2 feet thick	1,239	CY	\$	206	\$	255,374	MEANS 03.31.05.35.0300		Normal weight concrete and placement, 2 feet thick pad
Insulation	16,722	SF	\$	2	\$	33,444	MEANS 03.31.05.70.4300		
SUBTOTAL					\$	516,563			
New Vegetative Cap (Assumes 50% of the Property will include a Engineering Cap with Drainage Layer)									
Rough grading	24,774	SY	\$	5.15	\$	127,478	MEANS 17-03-0101		Silt fence around Quanta property included under engineered cap
Fine grading	24,774	SY	\$	1.42	\$	35,221	MEANS 17-03-0101		
Protective layer, 12" compacted soil subgrade	8,258	CY	\$	18	\$	146,188	MEANS 17-03-0423		
HDPE Liner, 40 mil thick	12,387	SY	\$	15	\$	191,133	ECHOS 33.08.0572		
Drainage layer, 6" granular soil (assume gravel)	2,065	CY	\$	53	\$	110,399	MEANS 32.11.23.23.1511		
Grade, Place Geotextile filter fabric	24,774	SY	\$	2.00	\$	49,548	Source 3		
Vegetative layer, 18" soil	12,387	CY	\$	18	\$	219,282	MEANS 17-03-0423		
Top soil, 6"	4,129	CY	\$	30	\$	123,871	MEANS 31.05.13.10.0800		
Dust suppression	45	DY	\$	820	\$	36,901	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
Hydroseed	222,968	SF	\$	0.07	\$	15,608	Source 3		
Watering	223	MSF	\$	55.84	\$	12,452	MEANS 32.01.09.26.4900		Based on 111,484-SF: 1" of water per 1,000 sf, 4 -watering events (.25-in per event)
SUBTOTAL					\$	1,068,081			
Compliance Monitoring and Health & Safety									
Environmental Controls	1	LS	\$	12,772	\$	12,772	Source 4		
Analytical Requirements	31,243	CY	\$	2.60	\$	81,232	Source 3		Based on total materials to be disposed
Install Decon Shed for workers (Mobilization & Demobilization)	1	LS	\$	500.00	\$	500	Source 3		
Decon Shed	9	MO	\$	1,043	\$	9,383	Source 4		
Air Monitoring	24	DY	\$	718	\$	17,220	Source 4 + CH2M H&S		
PPE Provisions for Workers (Initial)	20	EA	\$	252	\$	5,038	Source 4		10 labor, 4 operator, 4 trucks, 2 supervisor
PPE Provisions for Workers (Worker Days)	3,300	EA	\$	21.19	\$	69,940	Source 4 + CH2M H&S		
SUBTOTAL					\$	196,085			
CAPITAL SUBTOTAL - Soil									
Contingency	25%				\$	25,363,784			
SUBTOTAL					\$	6,340,946	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11		
					\$	31,704,730			
Project Management	5%				\$	1,585,236	USEPA 2000, p. 5-13, > \$10M		
Remedial Design	6%				\$	1,902,284	USEPA 2000, p. 5-13, > \$10M		
Construction Management	6%				\$	1,902,284	USEPA 2000, p. 5-13, > \$10M		
SUBTOTAL					\$	5,389,804			
Contractor Fees									
ODC & Subs	5%				\$	31,704,730			Calculate as 5% of capital cost
Labor	10%	max	\$	5,389,804	\$	538,980			Calculate as 10% of labor cost
SUBTOTAL					\$	2,124,217			
TOTAL CAPITAL COST - Soil					\$	39,218,750			

Alternative 3: Containment, Excavation, and In Situ Solidificaton/Stabilization - DRAFT

COST ESTIMATE SUMMARY

GROUNDWATER

General									
Mobilization/Demobilization	5%		\$	1,464,000	\$	73,200			Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$	1,464,000	\$	146,400			Calculate as 10% of capital cost
SUBTOTAL					\$	219,600			
Replacement Monitoring Wells									
Soil Borings	480	FT	\$	47	\$	22,320			Assumes 16 wells at 30-ft deep
2-inch PVC Well Casing	480	FT	\$	15	\$	7,109			
2-inch PVC Well Screen	160	FT	\$	25	\$	4,003			Assumes 10-ft screen
2-inch PVC Riser	320	FT	\$	15	\$	4,739			
Well cuttings disposal	16	EA	\$	100	\$	1,600			Assumes one 55-gal drum per well
Well development	16	EA	\$	1,600	\$	25,600			
SUBTOTAL					\$	65,371			
Site Preparation									
Erosion Control	1	LS	\$	20,000	\$	20,000			
Permitting	1	LS	\$	150,000	\$	150,000			
Survey (pre and post installation)	2	EA	\$	2,500	\$	5,000			
Staging Pad	1	LS	\$	10,000	\$	10,000			
Rental and operation of generator	1	MO	\$	17,050	\$	17,050			\$150/dy rent + \$400/dy fuel = \$550/dy
Rental of frac tank	1	MO	\$	500	\$	500			
Portadam® Barriers - Setup, teardown, and one month rental	1,200	LF	\$	100	\$	120,000			
Portadam® Barriers - Additional rental	2	WK	\$	15,600	\$	31,200			
Cut-Off Timber Piles Allowance	1	LS	\$	150,000	\$	150,000			
SUBTOTAL					\$	503,750			
Excavate 2' of Impacted Sediment									
Pump out area within Portadams®	30	DY	\$	1,275	\$	38,250	Source 3		750 GPM Godwin Dri-Prime 6" Model CD150M
Pump fuel and oil	1,500	GAL	\$	4	\$	6,000	Source 3		3.1 GPH Diesel Fuel x 24 hrs/day x 20 days
Excavate 2' sediment from dewatered area	11,000	CY	\$	25	\$	275,000	Source 3		Assumed area 160' x 950'
Transportation of material back to staging pad	11,000	CY	\$.4	\$	44,000	Source 3		
SUBTOTAL					\$	363,250			
Install RCM Mat & Armor Layer									
Organoclay RCM material	120	ROLL	\$	3,000	\$	360,000	Source 3		20% extra for overlap - 1,500 ft2/roll x \$2.00/ft2
Install organoclay RCM	150,000	SF	\$	1	\$	75,000	Source 3		
12" sand armor layer (material only)	6,000	CY	\$	20	\$	120,000	Source 3		
Install 12" sand armor layer	6,000	CY	\$	7	\$	42,000	Source 3		
SUBTOTAL					\$	597,000			
CAPTIAL SUBTOTAL - Groundwater					\$	1,748,971			
Contingency	25%				\$	437,243			10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11
SUBTOTAL					\$	2,186,213			
Project Management	5%				\$	109,311	USEPA 2000, p. 5-13, \$2M - \$10M		
Remedial Design	8%				\$	174,897	USEPA 2000, p. 5-13, \$2M - \$10M		
Construction Management	6%				\$	131,173	USEPA 2000, p. 5-13, \$2M - \$10M		
SUBTOTAL					\$	415,381			
Contractor Fees									
ODC & Subs	5%		\$	2,186,213	\$	109,311			Calculate as 5% of capital cost
Labor	10%	max	\$	415,381	\$	41,538			Calculate as 10% of labor cost
SUBTOTAL					\$	150,849			
TOTAL CAPITAL COST - GROUND WATER					\$	2,750,000			

NAPL

General									
Mobilization/Demobilization	5%		\$	4,736,651	\$	236,833			Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$	4,736,651	\$	473,665			Calculate as 10% of capital cost
SUBTOTAL					\$	710,498			
Funnel & Gate System (Organoclay Reactive Material)									
Site Preparation									
Erosion Control	1	LS	\$	10,000	\$	10,000			
Permitting	1	LS	\$	150,000	\$	150,000			
Survey (pre and post installation)	2	EA	\$	2,500	\$	5,000			
SUBTOTAL					\$	165,000			
Sheetpile and Reactive Gate Installation									
Trench Excavation	250	CY	\$	5.00	\$	1,250	CH2M HILL Est.		
Boulder Removal/Disposal	100	CY	\$	80.00	\$	8,000	CH2M HILL Est.		
Organoclay Reactive Material	90	LF	\$	1,004	\$	90,360	Vendor's Estimate		1.5' thick, 20 feet deep
On-site stabilization of excavated trench spoils with Portland Cement	4,280	CY	\$	40	\$	171,200	CH2M HILL Est.		
Sealed Sheet piling (Waterloo Barrier)	26,250	SF	\$	68	\$	1,785,000	Source 3		750 LF X 35' Depth for sheet pile
Backfill with stabilized material	1,979	TON	\$	12	\$	23,744	CH2M HILL Est.		
Disposal of stabilized material	3,957	TON	\$	130	\$	514,453	MEANS 33-19-7270		
Dust suppression	30	DY	\$	820	\$	24,600	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
SUBTOTAL					\$	2,618,607			
NAPL Recovery Trenches									
Preconstruction Investigations									
Slurry compatibility test	1	LS	\$	25,000	\$	25,000	CH2M Est.		
Pumping Test	1	LS	\$	75,000	\$	75,000	CH2M Est.		
Pilot Field Test	1	LS	\$	100,000	\$	100,000	CH2M Est., assumed design of test is included in design line item (@ 8%)		
Utility Markout / Locating Service	3	LS	\$	3,000	\$	9,000			
SUBTOTAL					\$	209,000			
Recovery Trench Installation									
On-Site Slurry Mixing Plant	1	LS	\$	144,000	\$	144,000	Assumed asphalt, concrete removal, site clearing is covered under soil		
Biopolymer Slurry (trench stabilization)	155,000	GAL	\$	0.06	\$	9,300	Estimator Judgment		
Trenching, for Recovery System	767	CY	\$	15	\$	11,505	Based on total trench volume, ECHOS		
Trench Backfill / Placement with Tremie Pipe	763	CY	\$	1.83	\$	1,396	MEANS		
Gravel, dumped and delivered	763	CY	\$	35	\$	26,361	MEANS, Backfill with gravel		
Geosynthetic Clay Liner	230	SF	\$	3.02	\$	696	MEANS		
Backfill with clean soil to grade	4	CY	\$	19	\$	76	Assume Claymax 200R or equivalent, Source 3		
Precast Concrete Sump (4'x4'x4') w/Aluminum manhole for well access	2	EA	\$	4,000	\$	8,000	Estimator Judgment		
Trench development	1	LS	\$	10,350	\$	10,350	Estimator Judgment		
24" SS Extraction Wells w/ Sumps	62	LF	\$	250	\$	15,500	Source 3		
Product Recovery Pumps	2	EA	\$	4,000	\$	8,000	Positive displacement piston pump, 1HP motor, 0-7 GPM		
SUBTOTAL					\$	235,185			

Alternative 3: Containment, Excavation, and In Situ Solidificaton/Stabilization - DRAFT

COST ESTIMATE SUMMARY

Install Equipment & Utilities for NAPL Collection/Handling									
Utility Trenching	1,153	CY	\$	7.04	\$	8,122	4 ft Deep, Includes Piping & Power Distribution, Source 3		
Electrical Conduit	3,040	LF	\$	1.68	\$	5,099	Assume power & controls wiring run in separate conduit, MEANS 260-533.10		
Backfill to grade	1,153	CY	\$	19.09	\$	22,017	Source 3		
NAPL Recovery Piping (Double walled)	1,075	LF	\$	50	\$	53,750	Assume 2" piping, material of construction		
Freeze Protection for Recovery Piping	1,075	LF	\$	3	\$	3,225	Heat trace		
Control System & Wiring (includes panels)	1	EA	\$	25,000	\$	25,000	Includes remote access & autodialer		
Control Wiring	2	EA	\$	800	\$	1,600			
Power Supply to the Site	1	LS	\$	16,000	\$	16,000	Includes distribution gear, disconnects to tie-in to central utility, Estimators		
Power Wiring, #10 Insulated Strand Wire	3,040	LF	\$	0.59	\$	1,794			
Electrical Disconnect, weatherhead, and installation of wiring	2	EA	\$	5,000.00	\$	10,000	Pumps are 1 HP, 230V or 460V, 3 Phase, Estimators Judgment		
Concrete Pad	1	LS	\$	25,000	\$	25,000	CH2M Est.		
Plumbing, Fire Suppression	1	LS	\$	10,000	\$	10,000	CH2M Est.		
Utility Connections	1	LS	\$	10,000	\$	10,000	CH2M Est.		
Permits	1	LS	\$	1,500	\$	1,500	CH2M Est.		
Storage Tanks, 200 gallon	1	EA	\$	4,970	\$	4,970	HDPE Tanks with ports for inlet / vent / level / outlet, Baliff Enterprises price		
Spare Product Recovery Pumps	2	EA	\$	4,000	\$	8,000	Positive displacement piston pump, 1HP motor, 0-7 GPM		
SUBTOTAL					\$	206,076			
Offsite Treatment / Disposal									
On-Site Waste Management - Soil	1,920	CY	\$	7.00	\$	13,442	Staging, dewatering		
On-Site Waste Management - Water	80,383	GAL	\$	1.00	\$	80,383	Engineers Estimate		
Off-site Disposal of Contaminated Water	80,383	GAL	\$	1.00	\$	80,383	Dewatering of Excavated Soil & Trench Dewatering & Decon Water		
Off-site Disposal of Soil	1,920	CY	\$	205	\$	393,668	Include soils from Trench Waste & Recovery Wells, assume sent to HW landfill		
Off-site Disposal of Municipal Waste	300	CY	\$	130	\$	39,000			
SUBTOTAL					\$	606,876			
System Startup									
	1	LS	\$	50,000	\$	50,000	Estimators Judgment		
Compliance Monitoring and Health & Safety									
Environmental Controls	1	LS	\$	11,577	\$	11,577	Source 4		
Analytical Requirements for Disposal	1,920	CY	\$	2.60	\$	4,993	Source 3		Based on total materials to be disposed
Install Decon Shed for workers	1	LS	\$	1,043	\$	1,043	Source 4		
Decon Shed	4	MO	\$	1,400	\$	5,600	Source 4		
Air Monitoring	16	DY	\$	718	\$	11,480	Source 4 + CH2M H&S		
PPE Provisions for Workers (Initial)	20	EA	\$	252	\$	5,038	Source 4		
PPE Provisions for Workers (Worker Days)	1,760	EA	\$	21	\$	37,301	Source 4 + CH2M H&S		
SUBTOTAL					\$	77,031			
NAPL Recovery Wells									
Preconstruction Investigations									
Pumping Test	1	LS	\$	75,000	\$	75,000	CH2M Est.		
Utility Markout / Locating Service	3	LS	\$	3,000	\$	9,000	Source 3		
SUBTOTAL					\$	84,000			
Sentinel Well Installation									
Soil Borings, 2" Diameter	105	LF	\$	22	\$	2,310	Air rotary rig and crew, wells are 15' deep, 7 wells		
2-inch SS Well Screen	63	LF	\$	25	\$	1,576	Well is screened from 4' bgs to bottom of well		
2-inch SS Well Riser	42	LF	\$	15	\$	622	4' of well riser		
Sand / Bentonite Materials	7	EA	\$	400	\$	2,800	Source 3		
Backfill borings, pea gravel	6	CY	\$	35	\$	207	Source 3		
Well development	7	EA	\$	1,600	\$	11,200	Source 3		
Flush mount completion	7	EA	\$	250	\$	1,750			
SUBTOTAL					\$	20,465			
Recovery Well Installation									
Soil Borings, 24" Diameter	210	LF	\$	300	\$	63,000	Air rotary rig and crew, wells are 15' deep, 14 wells		
8-inch SS Well Casing	210	LF	\$	197	\$	41,280	Casing along full length of well (15' deep), 14 wells, ECHOS		
8-inch SS Well Screen	154	LF	\$	197	\$	30,338	Well is screened from 4' bgs to bottom of well, 14 wells		
8-inch SS Well Riser	56	LF	\$	197	\$	11,032	4' of well riser, 14 wells		
Sand / Bentonite Materials	14	EA	\$	400	\$	5,600	Source 3		
Backfill borings, pea gravel	13	CY	\$	35	\$	449	Source 3		
Well development	14	EA	\$	1,600	\$	22,400	Source 3		
Product Recovery Pumps	7	EA	\$	4,000	\$	28,000	Positive displacement piston pump, 1HP motor, 0-7 GPM, vendor budgetary		
Roadboxes (for sump / well access)	7	EA	\$	2,500	\$	17,500	Assume asphalt cap under soil remediation costing ties into roadboxes		
SUBTOTAL					\$	219,599			
Install Equipment & Utilities for NAPL Collection/Handling									
Utility Trenching	133	CY	\$	11	\$	1,467	4 ft Deep, Includes Piping & Power Distribution, Source 3		
Electrical Conduit	600	LF	\$	8.00	\$	4,800	ECHOS 20.02.0610		
Backfill to grade	160	CY	\$	19	\$	3,054	Use 1.2X compaction factor		
Control Wiring	7	EA	\$	500	\$	3,500			
Power Supply to the Site	1	LS	\$	16,000	\$	16,000	Includes gear/disconnects to tie-in to central utility, Estimators Judgment		
Power Wiring, #10 Insulated Strand Wire	600	LF	\$	1	\$	354	Source 3		
Electrical Disconnect, weatherhead, and installation of wiring	7	EA	\$	5,000	\$	35,000	Pumps are 1 HP, 230V or 460V, 3 Phase, Estimators Judgment		
Spare Product Recovery Pumps	2	EA	\$	4,000	\$	8,000	Positive displacement piston pump, 1HP motor, 0-7 GPM		
SUBTOTAL					\$	72,175			
Offsite Treatment / Disposal									
On-Site Waste Management - Soil	146	CY	\$	7.00	\$	1,024	Transfer to drums for disposal		
Off-site Disposal of Soil	146	CY	\$	205	\$	29,998	Include soils from Recovery Well installation & trenching, assume sent to HW		
Off-site Disposal of Municipal Waste	240	CY	\$	130	\$	31,200	Assume 2 rollofs per month		
Off-site Disposal of NAPL (well development)	5	GAL	\$	2.00	\$	10	Source 3		
SUBTOTAL					\$	62,233			
System Startup									
	1	LS	\$	50,000	\$	50,000	Estimators Judgment		
Compliance Monitoring and Health & Safety									
Environmental Controls	1	LS	\$	11,577	\$	11,577	Source 4		
Analytical Requirements for Disposal	146	CY	\$	2.60	\$	380	Source 3		Based on total materials to be disposed
Install Decon Shed for workers	1	LS	\$	1,043	\$	1,043	Source 4		
Decon Shed	4	MO	\$	1,043	\$	4,170	Source 4		
Air Monitoring	16	DY	\$	718	\$	11,480	Source 4 + CH2M H&S		
PPE Provisions for Workers (Initial)	15	EA	\$	252	\$	3,778	Source 4		
PPE Provisions for Workers (Worker Days)	1,320	EA	\$	21	\$	27,976	Source 4 + CH2M H&S		
SUBTOTAL					\$	60,404			
CAPITAL SUBTOTAL - NAPL									
Contingency	25%				\$	5,426,683			
SUBTOTAL					\$	1,356,671	10% Scope + 15% Bid		
Project Management	5%				\$	339,168	USEPA 2000, p. 5-13, \$2M - \$10M		
Remedial Design	8%				\$	542,668	USEPA 2000, p. 5-13, \$2M - \$10M		
Construction Management	6%				\$	407,001	USEPA 2000, p. 5-13, \$2M - \$10M		
SUBTOTAL					\$	1,288,837			
Contractor Fees									
ODC & Subs	5%		\$	6,783,354	\$	339,168			Calculate as 5% of capital cost
Labor	10%	max	\$	1,288,837	\$	128,884			Calculate as 10% of labor cost
SUBTOTAL					\$	468,051			
TOTAL CAPITAL COST - NAPL									
					\$	8,540,000			

Alternative 3: Containment, Excavation, and In Situ Solidificaton/Stabilization - DRAFT						COST ESTIMATE SUMMARY	
SOIL							
OPERATIONS AND MAINTENANCE COST							
DESCRIPTION		QTY	UNIT	UNIT COST	TOTAL	NOTES	
Cap Maintenance							
Cap Repair		1	LS	\$ 19,709	\$ 19,709	Assumes 1% of area requires repair annually, cap costs are based on repaving and maintaining the soil cap at Quanta	
Cap Inspection and Repair Report		1	LS	\$ 2,000	\$ 2,000		
Fan System Maintenance (115 River Road)		8	HR	\$ 80	\$ 640		
SUBTOTAL					\$ 22,349		
Contingency		25%			\$ 5,587	10% Scope + 15% Bid	
SUBTOTAL					\$ 27,936		
Project Management		5%			\$ 1,397		
Technical Support		25%			\$ 6,984		
SUBTOTAL					\$ 8,381		
Contractor Fees							
ODC & Subs		5%		\$ 27,936	\$ 1,397	Calculate as 5% of capital cost	
Labor		10%	max	\$ 8,381	\$ 838	Calculate as 10% of labor cost	
SUBTOTAL					\$ 2,235		
TOTAL ANNUAL O&M COST - Soil (Year 1 to 30)					\$ 38,600		
PERIODIC COSTS							
DESCRIPTION		YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
2 Year Biennial Certification		2	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		4	1	LS	\$ 4,613	\$ 4,613	
5 year Review		5	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification		6	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		8	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		10	1	LS	\$ 4,613	\$ 4,613	
5 year Review		10	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification		12	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		14	1	LS	\$ 4,613	\$ 4,613	
5 year Review		15	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road		15	1	LS	\$ 5,000	\$ 5,000	
2 Year Biennial Certification		16	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		18	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		20	1	LS	\$ 4,613	\$ 4,613	
5 year Review		20	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification		22	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		24	1	LS	\$ 4,613	\$ 4,613	
5 year Review		25	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification		26	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		28	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification		30	1	LS	\$ 4,613	\$ 4,613	
5 year Review		30	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road		30	1	LS	\$ 5,000	\$ 5,000	
Asphalt Cap Replacement		30	1	LS	\$ 895,830	\$ 895,830	Assume complete replacement of 30% of cap after 30 years
						\$ 1,065,028	
TOTAL ANNUAL PERIODIC COST					\$ 1,065,000		
PRESENT VALUE ANALYSIS							
				Discount Rate =	7.0%		
COST TYPE		YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST		0	\$ 39,218,750	\$ 39,218,750	1.00	\$ 39,218,750	
ANNUAL O&M COST - Cap		1 to 30	\$ 1,158,000	\$ 38,600	12.41	\$ 478,989	
PERIODIC COST		2	\$ 4,613	\$ 4,613	0.87	\$ 4,029	
PERIODIC COST		4	\$ 4,613	\$ 4,613	0.76	\$ 3,519	
PERIODIC COST		5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST		6	\$ 4,613	\$ 4,613	0.67	\$ 3,074	
PERIODIC COST		8	\$ 4,613	\$ 4,613	0.58	\$ 2,685	
PERIODIC COST		10	\$ 19,613	\$ 19,613	0.51	\$ 9,970	
PERIODIC COST		12	\$ 4,613	\$ 4,613	0.44	\$ 2,048	
PERIODIC COST		14	\$ 4,613	\$ 4,613	0.39	\$ 1,789	
PERIODIC COST		15	\$ 20,000	\$ 20,000	0.36	\$ 7,249	
PERIODIC COST		16	\$ 4,613	\$ 4,613	0.34	\$ 1,563	
PERIODIC COST		18	\$ 4,613	\$ 4,613	0.30	\$ 1,365	
PERIODIC COST		20	\$ 19,613	\$ 19,613	0.26	\$ 5,068	
PERIODIC COST		22	\$ 4,613	\$ 4,613	0.23	\$ 1,041	
PERIODIC COST		24	\$ 4,613	\$ 4,613	0.20	\$ 909	
PERIODIC COST		25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST		26	\$ 4,613	\$ 4,613	0.17	\$ 794	
PERIODIC COST		28	\$ 4,613	\$ 4,613	0.15	\$ 694	
PERIODIC COST		30	\$ 920,444	\$ 920,444	0.13	\$ 120,916	
						\$ 39,877,913	
TOTAL PRESENT VALUE FOR SOIL					\$ 39,880,000		

GROUNDWATER

OPERATIONS AND MAINTENANCE COST

Inspection of Subaqueous Reactive Barrier (SRB)

Sampling of barrier during low tide	1	LS	\$	15,000	\$	15,000	Excavator onsite for 5 days--expose 5% of barrier every 5 years
Barrier replacement	1	LS	\$	149,250	\$	149,250	25% of barrier every 5 years
SUBTOTAL					\$	164,250	
Allowance for Misc. Items	20%				\$	32,850	
SUBTOTAL					\$	197,100	
Contingency	25%				\$	49,275	10% Scope + 15% Bid
SUBTOTAL					\$	246,375	
Project Management	5%				\$	12,319	
Technical Support	25%				\$	61,594	
SUBTOTAL					\$	73,913	

Contractor Fees

ODC & Subs	5%		\$	246,375	\$	12,319	Calculate as 5% of capital cost
Labor	10%	max	\$	73,913	\$	7,391	Calculate as 10% of labor cost
SUBTOTAL					\$	19,710	

TOTAL FOR SRB O&M \$ 340,000

Groundwater Monitoring

Groundwater Samples	16	EA	\$	645	\$	10,320	Pesticides, TAL Metals
QC Samples	5	EA	\$	645	\$	3,225	Historical Pricing
Groundwater Sampling, Level D							
Labor	150	HR	\$	80	\$	12,000	CH2M Est. - 3 persons for 5 days
Equipment - meters	1	LS	\$	500	\$	500	CH2M Est.
Consumables	1	LS	\$	200	\$	200	CH2M Est.
Data Validation	24	HR	\$	80	\$	1,920	CH2M Est.
Reporting	50	HR	\$	80	\$	4,000	CH2M Est.
SUBTOTAL					\$	32,165	
Allowance for Misc. Items	20%				\$	6,433	
SUBTOTAL					\$	38,598	
Contingency	25%				\$	9,650	10% Scope + 15% Bid
SUBTOTAL					\$	48,248	
Project Management	5%				\$	2,412	
Technical Support	25%				\$	12,062	
					\$	14,474	

Contractor Fees

ODC & Subs	5%		\$	48,248	\$	2,412	Calculate as 5% of capital cost
Labor	10%	max	\$	14,474	\$	1,447	Calculate as 10% of labor cost
SUBTOTAL					\$	3,860	

TOTAL FOR GROUNDWATER SAMPLING EVENT \$ 66,600

TOTAL ANNUAL O&M COST Year 0 to 2	\$ 266,400	Quarterly for 2 years
TOTAL ANNUAL O&M COST Year 3 to 30	\$ 66,600	Annually
TOTAL ANNUAL O&M COST Year 5, 10, 15, 20, 25, 30	\$ 340,000	Cap maintenance

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 year Review	5	1	LS	\$ 15,000	\$ 15,000	
5 year Review	10	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	10	1	LS	\$ 25,000	\$ 25,000	
5 year Review	15	1	LS	\$ 15,000	\$ 15,000	
5 year Review	20	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	20	1	LS	\$ 25,000	\$ 25,000	
5 year Review	25	1	LS	\$ 15,000	\$ 15,000	
5 year Review	30	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	30	1	LS	\$ 25,000	\$ 25,000	
					\$ 165,000	
TOTAL ANNUAL PERIODIC COST					\$ 170,000	

Alternative 3: Containment, Excavation, and In Situ Solidificaton/Stabilization - DRAFT

COST ESTIMATE SUMMARY

PRESENT VALUE ANALYSIS						
Discount Rate = 7.0%						
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 2,750,000	\$ 2,750,000	1.00	\$ 2,750,000	
ANNUAL O&M COST (Year 0-2)	0 to 2	\$ 532,800	\$ 266,400	1.81	\$ 481,656	
ANNUAL O&M COST (Year 3-30)	3 to 30	\$ 1,864,800	\$ 66,600	10.60	\$ 706,028	
ANNUAL O&M COST (Year 5)	5	\$ 340,000	\$ 340,000	0.71	\$ 242,415	
ANNUAL O&M COST (Year 10)	10	\$ 340,000	\$ 340,000	0.51	\$ 172,839	
ANNUAL O&M COST (Year 15)	15	\$ 340,000	\$ 340,000	0.36	\$ 123,232	
ANNUAL O&M COST (Year 20)	20	\$ 340,000	\$ 340,000	0.26	\$ 87,862	
ANNUAL O&M COST (Year 25)	25	\$ 340,000	\$ 340,000	0.18	\$ 62,645	
ANNUAL O&M COST (Year 30)	30	\$ 340,000	\$ 340,000	0.13	\$ 44,665	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 40,000	\$ 40,000	0.51	\$ 20,334	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 40,000	\$ 40,000	0.26	\$ 10,337	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 40,000	\$ 40,000	0.13	\$ 5,255	
					\$ 4,726,163	
TOTAL PRESENT VALUE FOR GROUNDWATER					\$ 4,730,000	

NAPL						
Funnel Gate Organoclay Reactive Material						
Sampling of Reactive Material		1	LS	\$ 10,000	\$ 10,000	3 locations 6 samples, 20-ft deep
SUBTOTAL					\$ 10,000	
NAPL Recovery						
Electricity - Pump Operation (1.5 HP pump)		7	EA	\$ 1,618	\$ 11,329	MEANS 33-42-0102
Misc. Electrical Site Usage		12	MO	\$ 3,660	\$ 43,924	MEANS 33-42-0106
					\$ 48,000	Assumes part time operator performs duties for NAPL system (5 days/month)
Routine Operations, Maintenance, Monitoring		600	HR	\$ 80		
Parts Replacement / Consumables		1	LS	\$ 5,000	\$ 5,000	
O&M Project Management		1	LS	\$ 7,200	\$ 7,200	15% of O&M
Electricity		12	MO	\$ 1,500	\$ 18,000	MEANS 33-42-0106
Reporting		1	LS	\$ 20,000	\$ 20,000	CH2M Est.
Pumping & Transport of NAPL (Vac Truck)		1,000	GAL	\$ 1.00	\$ 1,000	Assume each truck 1000 gallons
Off-site Disposal of NAPL		2,000	GAL	\$ 2.00	\$ 4,000	
SUBTOTAL					\$ 158,453	
SUBTOTAL ANNUAL O&M					\$ 168,453	
Contingency		25%			\$ 42,113	10% Scope + 15% Bid
SUBTOTAL					\$ 210,566	
Project Management		5%			\$ 10,528	
Technical Support		25%			\$ 52,641	
					\$ 63,170	
Contractor Fees						
ODC & Subs		5%		\$ 210,566	\$ 10,528	Calculate as 5% of capital cost
Labor		10%	max	\$ 63,170	\$ 6,317	Calculate as 10% of labor cost
SUBTOTAL					\$ 16,845	
TOTAL ANNUAL O&M COST (Year 0 to 30)					\$ 290,000	

PERIODIC COSTS						
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES	
5 year Review	5	1	LS \$	15,000 \$	15,000	
5 year Review	10	1	LS \$	15,000 \$	15,000	
Replacement of Reactive Material	10	1	LS \$	27,108 \$	27,108	30% replaced
5 year Review	15	1	LS \$	15,000 \$	15,000	
5 year Review	20	1	LS \$	15,000 \$	15,000	
Replacement of Reactive Material	20	1	LS \$	27,108 \$	27,108	30% replaced
5 year Review	25	1	LS \$	15,000 \$	15,000	
5 year Review	30	1	LS \$	15,000 \$	15,000	
Replacement of Reactive Material	30	1	LS \$	27,108 \$	27,108	30% replaced
SUBTOTAL				\$ 171,324		
TOTAL ANNUAL PERIODIC COST				\$ 171,000		

PRESENT VALUE ANALYSIS						
Discount Rate = 7.0%						
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 8,540,000	\$ 8,540,000	1.0	\$ 8,540,000	
ANNUAL O&M COST	1 to 30	\$ 8,700,000	\$ 290,000	12.41	\$ 3,598,622	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 42,108	\$ 42,108	0.51	\$ 21,406	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 42,108	\$ 42,108	0.26	\$ 10,882	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 42,108	\$ 42,108	0.13	\$ 5,532	
					\$ 12,195,336	
TOTAL PRESENT VALUE OF NAPL					\$ 12,200,000	

Total Present Value for Alternative 3	\$56,810,000
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SOURCE INFORMATION	
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).	
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)	
2b. R.S. Means Company. 2007. 26th Edition.	
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.	
3. Historical CH2M HILL project cost information	
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)	

Alternative 4 - In Situ Solidification/Stabilization

COST ESTIMATE SUMMARY

Site:
Quanta Resources Site-Edgewater, New Jersey
Phase:
Preliminary Draft Feasibility Study Report
Base Year:
2008
Date:
2/10/2008

Description:
-In situ solidification/stabilization of tar boils, NZ-1, NZ-2, and NZ-5. Institutional controls would be established and maintained to document and limit use of areas with contamination remaining in place.
-Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic cap would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with contamination remaining in place.
-Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
-The basements in the 115 River Road building would be converted to crawl spaces with active ventilation. Institutional controls would be established and maintained to control new construction and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and former Lever Brother properties, as needed.
-A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established. SHEET PILE AND DISPOSAL OF SEDIMENT ARE NOT INCLUDED IN THIS ESTIMATE.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
General Site Work						
Mobilization/Demobilization	5%		\$ 18,029,317	\$ 901,466		Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$ 18,029,317	\$ 1,802,932		Calculate as 10% of capital cost
SUBTOTAL				\$ 2,704,398		
Site Establishment						
Survey	200	DY	\$ 1,500	\$ 300,000	CCI Historical	
Fencing	6,000	LF	\$ 15	\$ 90,000	CCI Historical	
Trailer Installation & Setup	1	EA	\$ 3,000	\$ 3,000	CH2M Est.	
Support Area Establishment and Site Offices	24	MO	\$ 4,300	\$ 103,200	CH2M Est.	Tie-downs, stairs, power
SUBTOTAL				\$ 496,200		Includes shed, utilities, lavatories
Institutional Controls (Quanta, 115 River Road, Edgewater, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW, Former Lever Bros)						
Deed Notices (1 for each property)	9	LS	\$ 25,000	\$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
SUBTOTAL				\$ 225,000		
Clearing & Vegetation/Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	\$ 1.28	\$ 3,369	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and Grub Heavy Brush & Trees (includes chipper)	3	AC	\$ 8,203	\$ 24,610	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, assumes 20% of Quanta requires clearing
Tank pad concrete removal & sizing to less than 2 feet	5,645	TON	\$ 128	\$ 720,634	MEANS 02.41.13.17.5500	Concrete demolition, on grade slab, assumes 2" thick concrete pads on 20% of Quanta site, 15% of pads are removed
Asphalt removal	3,969	SY	\$ 3.76	\$ 14,925	Source 3	Assumes 3" thick asphalt to be cleared from 15% of Quanta
Subsurface piping abandonment	1	LS	\$ 250,000	\$ 250,000		Engineer's Estimate
Offsite disposal of cleared materials, concrete (including transportation to < 50 miles)	3,528	CY	\$ 205	\$ 723,316	MEANS 33-19-7270	Assumes HW landfill: Concrete pads + Clearing lat 30 CY/AC
Asphalt Disposal	331	CY	\$ 25	\$ 8,275	Source 3	
Dust suppression	20	DY	\$ 820	\$ 16,400	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				\$ 1,761,529		
Site Clearing & Disposal (Block 93, 115 River Road)						
Temporary erosion controls (silt fencing)	2,100	LF	\$ 1.28	\$ 2,696	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	12,578	SY	\$ 3.76	\$ 47,294	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 and 115 River Road
Asphalt Disposal	1,048	CY	\$ 25	\$ 26,200	Source 3	
Dust suppression	5	DY	\$ 820	\$ 4,100	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				\$ 80,290		
Site Clearing & Disposal (Edgewater - Arsenic Area)						
Temporary erosion controls (silt fencing)	1,500	LF	\$ 1.28	\$ 1,926	MEANS 31.25.13.10.1100	Surrounding property boundary
Concrete removal & sizing to less than 2"	6,061	TON	\$ 118	\$ 715,159	MEANS 02.41.13.17.5500	Concrete demolition of access ramp, assumes 2-ft of concrete
Asphalt removal	6,361	SY	\$ 3.76	\$ 23,918	Source 3	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Offsite disposal of concrete (including transportation to < 50 miles)	3,367	CY	\$ 130	\$ 437,715	MEANS 33-19-7270	Assumes non-HW landfill
Asphalt Disposal	530	CY	\$ 25	\$ 13,250	Source 3	
Dust suppression	40	DY	\$ 820	\$ 32,801	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	10	DY	\$ 3,000	\$ 30,000	Source 3	
Excavation, stockpile and backfill of 10-ft of soils above the existing arsenic liner	21,204	CY	\$ 35	\$ 750,473	MEANS 17-03-0276	Assumes material will be replaced following the completion of arsenic stabilization
Temporary Access	1	allow	\$ 65,000	\$ 65,000		
SUBTOTAL				\$ 2,070,241		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	750	LF	\$ 1.28	\$ 963	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	1,505	SY	\$ 3.76	\$ 5,660	Source 3	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Asphalt Disposal	125	CY	\$ 25	\$ 3,125	Source 3	
Dust suppression	20	DY	\$ 820	\$ 16,400	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	5	DY	\$ 3,000	\$ 15,000	Source 3	
Excavation and stockpile of 10-ft of backfill	5,018	CY	\$ 35	\$ 177,610	MEANS 17-03-0276	Assumes material can be replaced
SUBTOTAL				\$ 218,758		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	500	LF	\$ 1.28	\$ 642	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	764	SY	\$ 3.76	\$ 2,872	Source 3	Assumes 3" thick asphalt to be cleared
Asphalt Disposal	64	CY	\$ 25	\$ 1,600	Source 3	
Dust suppression	7	DY	\$ 820	\$ 5,740	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	1	DY	\$ 3,000	\$ 3,000	Source 3	
SUBTOTAL				\$ 13,854		

Alternative 4 - In Situ Solidification/Stabilization

COST ESTIMATE SUMMARY

Capping

New Engineered Impermeable Cap (115 River Road, Block 93)

Rough site grading	27,875	SY	\$	5.15	\$	143,433	MEANS 17-03-0101
Fine grading	27,875	SY	\$	1.42	\$	39,629	MEANS 17-03-0101
Gravel Base, 6 inches	4,646	CY	\$	53	\$	248,441	MEANS 32.11.23.23.1511
Dust suppression	32	DY	\$	820	\$	26,240	MEANS 31.23.23.18.4500
Storm water control (3' x 3' culverts, rip-rap)	8	EA	\$	11,638	\$	93,101	Source 4
Asphalt stabilized binder course, 2" thick	27,875	SY	\$	23	\$	638,031	MEANS 32.12.16.13.0120
Asphalt wear course, 2" thick	27,875	SY	\$	23	\$	653,153	MEANS 32.12.16.13.0380
Install Asphalt Curb/Berm on Perimeter	4,300	LF	\$	11	\$	47,472	MEANS 32.16.19.10.0150
SUBTOTAL					\$	1,889,502	

Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above

Assume no fill needed for grading
Assume no fill needed for grading

Concurrent site activities/dust control
Included 2 storm water control systems per capped property

Replacement of Access Ramp and Parking Lots (Edgewater)

Backfilling and compaction of excavated material	21,204	CY	\$	18	\$	375,358	MEANS 17-03-0423
Rough site grading	8,275	SY	\$	5.15	\$	42,580	MEANS 17-03-0101
Fine grading	8,275	SY	\$	1.42	\$	11,764	MEANS 17-03-0101
Gravel Base, 6 inches	1,379	CY	\$	53	\$	73,741	MEANS 32.11.23.23.1511
Dust suppression	60	DY	\$	820	\$	49,201	MEANS 31.23.23.18.4500
Storm water control (3' x 3' culverts, rip-rap)	2	EA	\$	11,638	\$	23,275	Source 4
Asphalt stabilized binder course, 2" thick	8,275	SY	\$	23	\$	189,407	MEANS 32.12.16.13.0120
Asphalt wear course, 2" thick	8,275	SY	\$	23	\$	193,896	MEANS 32.12.16.13.0380
Install Asphalt Curb/Berm on Perimeter	2,500	LF	\$	11	\$	27,600	MEANS 32.16.19.10.0150
SUBTOTAL					\$	986,821	

Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above

Assumes 1.2x excavated material required for compaction

Assume no fill needed for grading
Assume no fill needed for grading

Concurrent site activities/dust control
Included 2 storm water control systems per capped property

New Cap (115 River Road Property - Basement Area)

Clear & disposal of basement materials (equipment, etc.)	16,722	SF	\$	0.43	\$	7,239	MEANS 02.41.19.19.0300
Abandon/Demo Basement Facility Trench Drains (trenching, concrete, grating)	1,700	LF	\$	68	\$	115,600	MEANS 22.14.26.19.6650
Disposal of Basement Demo Material	1	LS	\$	10,000	\$	10,000	Estimator Judgement
Install HDPE liner	1,858	SF	\$	15	\$	28,669	MEANS 02.660.610.1200
Fill Basement with 2 feet of Fill	1,239	CY	\$	53	\$	66,237	MEANS 32.11.23.23.1511
Fill Basement with 2 feet of Concrete	1,239	CY	\$	206	\$	255,374	MEANS 03.31.05.35.0300
Insulation	16,722	SF	\$	2	\$	33,444	
SUBTOTAL					\$	516,563	

Assumption: 1 ton of mtrl & equip/250sf (15.81' x 15.81')

Normal weight concrete and placement

New Vegetative Cap (Assumes 50% of the Property will include a Engineering Cap with Drainage Layer)

Rough grading	24,774	SY	\$	5.15	\$	127,478	MEANS 17-03-0101
Fine grading	24,774	SY	\$	1.42	\$	35,221	MEANS 17-03-0101
Protective layer, 12" compacted soil subgrade	8,258	CY	\$	18	\$	146,188	MEANS 17-03-0423
HDPE Liner, 40 mil thick	12,387	SY	\$	15	\$	191,133	ECHOS 33.08.0572
Drainage layer, 6" granular soil (assume gravel)	2,065	CY	\$	53	\$	110,399	MEANS 32.11.23.23.1511
Grade, Place Geotextile filter fabric	24,774	SY	\$	2.00	\$	49,548	Source 3
Vegetative layer, 18" soil	12,387	CY	\$	18	\$	219,282	MEANS 17-03-0423
Top soil, 6"	4,129	CY	\$	30	\$	123,871	MEANS 31.05.13.10.0800
Dust suppression	45	DY	\$	820	\$	36,901	MEANS 31.23.23.18.4500
Hydroseed	222,968	SF	\$	0.07	\$	15,608	Source 3
Watering	223	MSF	\$	56	\$	12,452	MEANS 32.01.09.26.4900
SUBTOTAL					\$	1,068,081	

Silt fence around Quanta property included under engineered cap

Concurrent site activities/dust control

Based on 1" of water per 1,000 sf, 4 - watering events (.25-in per event)

In-Situ Treatment

In-Situ Stabilization (Arsenic Materials > 336 mg/kg) (Quanta and Block 93 North)

Set-up Fee	1	LS	\$	40,000	\$	40,000	CH2M HILL Est.
Jet Grout around Utilities	300	LF	\$	35	\$	10,500	CH2M HILL Est.
Reagent at 5% Additive - Ferrous Sulfate	22,441	CY	\$	22	\$	486,970	Source 3
Reagent at 15% Additive - Cement	22,441	CY	\$	30	\$	666,498	Source 3
In-Situ Mixing	22,441	CY	\$	30	\$	673,230	Vendor
Tear-Down/Decon	1	LS	\$	2,500	\$	2,500	Source 3
SUBTOTAL					\$	1,879,697	

Assume mixing with 8-ft mixing auger

In-Situ Stabilization (Arsenic Materials > 336 mg/kg) (Edgewater)

Set-up Fee	1	LS	\$	40,000	\$	40,000	CH2M HILL Est.
Jet Grout around Utilities	1,200	LF	\$	35	\$	42,000	CH2M HILL Est.
Reagent at 5% Additive - Ferrous Sulfate	16,835	CY	\$	22	\$	365,320	Source 3
Reagent at 15% Additive - Cement	16,835	CY	\$	30	\$	500,000	Source 3
In-Situ Mixing	16,835	CY	\$	30	\$	505,050	Vendor
Tear-Down/Decon	1	LS	\$	2,500	\$	2,500	Source 3
SUBTOTAL					\$	1,454,869	

Assume mixing with 8-ft mixing auger

In-Situ Stabilization (NAPL Areas) (NZ-1, NZ-2, NZ-5, and tar boils)

Set-up Fee	1	LS	\$	15,000	\$	15,000	Source 3
Jet Grouting	1,600	LF	\$	35	\$	56,000	CH2M HILL Est.
Reagent at 15% Additive - Cement	78,505	CY	\$	30	\$	2,331,599	Source 3
In-Situ Mixing	78,505	CY	\$	30	\$	2,355,150	Vendor
Tear-Down/Decon	1	LS	\$	17,500	\$	17,500	Source 3
SUBTOTAL					\$	4,775,249	

Assume mixing with 8-ft mixing auger

Alternative 4 - In Situ Solidification/Stabilization

COST ESTIMATE SUMMARY

Compliance Monitoring and Health & Safety					
Environmental Controls	1	LS	\$	12,772	\$ 12,772 Source 4
Analytical Requirements	238	EA	\$	25	\$ 5,959 Vendor
Install Decon Shed for workers (Mobilization & Demobilization)	1	LS	\$	500	\$ 500 Source 3
Decon Shed	24	MO	\$	1,043	\$ 25,021 Source 4
Air Monitoring	383	DY	\$	718	\$ 274,803 Source 4 + CH2M H&S
PPE Provisions for Workers (Initial)	20	EA	\$	252	\$ 5,038 Source 4
PPE Provisions for Workers (Worker-Days)	12,672	EA	\$	21	\$ 268,569 Source 4 + CH2M H&S
SUBTOTAL					\$ 592,662
CAPITAL SUBTOTAL - Soil					
Contingency	All Tasks			\$	20,733,715
SUBTOTAL	25%			\$	5,183,429 10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11
				\$	25,917,144
Project Management	5%			\$	1,295,857 USEPA 2000, p. 5-13, >\$10M
Remedial Design	6%			\$	1,555,029 USEPA 2000, p. 5-13, >\$10M
Construction Management	6%			\$	1,555,029 USEPA 2000, p. 5-13, >\$10M
SUBTOTAL				\$	4,405,914
Contractor Fees					
ODC & Subs	5%			\$	25,917,144
Labor	10%	max		\$	440,591
SUBTOTAL				\$	1,736,449
TOTAL CAPITAL COST - Soil				\$	32,060,000

GROUNDWATER

General					
Mobilization/Demobilization	5%			\$	1,464,000
Subcontractor General Conditions	10%			\$	146,400
SUBTOTAL				\$	219,600
Replacement Monitoring Wells					
Soil Borings	480	FT	\$	47	\$ 22,320
2-inch PVC Well Casing	480	FT	\$	15	\$ 7,109
2-inch PVC Well Screen	160	FT	\$	25	\$ 4,003
2-inch PVC Riser	320	FT	\$	15	\$ 4,739
Well cuttings disposal	16	EA	\$	100	\$ 1,600
Well development	16	EA	\$	1,600	\$ 25,600
SUBTOTAL				\$	65,371
Site Preparation					
Erosion Control	1	LS	\$	20,000	\$ 20,000
Permitting	1	LS	\$	150,000	\$ 150,000
Survey (pre and post installation)	2	EA	\$	2,500	\$ 5,000
Staging Pad	1	LS	\$	10,000	\$ 10,000
Rental and operation of generator	1	MO	\$	17,050	\$ 17,050
Rental of frac tank	1	MO	\$	500	\$ 500
Portadam® Barriers - Setup, teardown, and one month rental	1,200	LF	\$	100	\$ 120,000
Portadam® Barriers - Additional rental	2	WK	\$	15,600	\$ 31,200
Cut-Off Timber Piles Allowance	1	LS	\$	150,000	\$ 150,000
SUBTOTAL				\$	503,750
Excavate 2' of Impacted Sediment					
Pump out area within Portadams®	30	DY	\$	1,275	\$ 38,250 Source 3
Pump fuel and oil	1,500	GAL	\$	4	\$ 6,000 Source 3
Excavate 2' sediment from dewatered area	11,000	CY	\$	25	\$ 275,000 Source 3
Transportation of material back to staging pad	11,000	CY	\$	4	\$ 44,000 Source 3
SUBTOTAL				\$	363,250
Install RCM Mat & Armor Layer					
Organoclay RCM material	120	ROLL	\$	3,000	\$ 360,000 Source 3
Install organoclay RCM	150,000	SF	\$	1	\$ 75,000 Source 3
12" sand armor layer (material only)	6,000	CY	\$	20	\$ 120,000 Source 3
Install 12" sand armor layer	6,000	CY	\$	7	\$ 42,000 Source 3
SUBTOTAL				\$	597,000
CAPITAL SUBTOTAL - Groundwater					
Contingency	25%			\$	1,748,971
SUBTOTAL				\$	437,243 10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11
				\$	2,186,213
Project Management	5%			\$	109,311 USEPA 2000, p. 5-13, \$2M - \$10M
Remedial Design	8%			\$	174,897 USEPA 2000, p. 5-13, \$2M - \$10M
Construction Management	6%			\$	131,173 USEPA 2000, p. 5-13, \$2M - \$10M
SUBTOTAL				\$	415,381
Contractor Fees					
ODC & Subs	5%			\$	2,186,213
Labor	10%	max		\$	415,381
SUBTOTAL				\$	150,849
TOTAL CAPITAL COST - GROUND WATER				\$	2,750,000

Alternative 4 - In Situ Solidification/Stabilization

COST ESTIMATE SUMMARY

SOIL

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Cap Maintenance					
Cap Repair	1	LS	\$ 16,745	\$ 16,745	Assumes 1% of area requires repair annually, cap costs are based on repaving and soil cap at Quanta
Cap Inspection and Repair Report	1	LS	\$ 2,000	\$ 2,000	
Fan System Maintenance (115 River Road)	8	HR	\$ 80	\$ 640	
SUBTOTAL				\$ 19,385	
Contingency	25%			\$ 4,846	10% Scope + 15% Bid
SUBTOTAL				\$ 24,231	
Project Management	5%			\$ 1,212	
Technical Support	25%			\$ 6,058	
SUBTOTAL				\$ 7,269	
Contractor Fees					
ODC & Subs	5%		\$ 24,231	\$ 1,212	Calculate as 5% of capital cost
Labor	10%	max	\$ 7,269	\$ 727	Calculate as 10% of labor cost
SUBTOTAL				\$ 1,938	
TOTAL ANNUAL O&M COST (Year 1 to 30)				\$ 33,400	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
2 Year Biennial Certification	2	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	4	1	LS	\$ 4,613	\$ 4,613	
5 year Review	5	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	6	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	8	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	10	1	LS	\$ 4,613	\$ 4,613	
5 year Review	10	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	12	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	14	1	LS	\$ 4,613	\$ 4,613	
5 year Review	15	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road	15	1	LS	\$ 5,000	\$ 5,000	
2 Year Biennial Certification	16	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	18	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	20	1	LS	\$ 4,613	\$ 4,613	
5 year Review	20	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	22	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	24	1	LS	\$ 4,613	\$ 4,613	
5 year Review	25	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	26	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	28	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	30	1	LS	\$ 4,613	\$ 4,613	
5 year Review	30	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road	30	1	LS	\$ 5,000	\$ 5,000	
Asphalt Cap Replacement	30	1	LS	\$ 887,275	\$ 887,275	Assume complete replacement of 30% of cap after 30 years
TOTAL ANNUAL PERIODIC COST					\$ 1,056,473	

PRESENT VALUE ANALYSIS

Discount Rate = 7.0%

Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 32,060,000	\$ 32,060,000	1	\$ 32,060,000	
ANNUAL O&M COST - Cap	1 to 30	\$ 1,002,000	\$ 33,400	12.41	\$ 414,462	
PERIODIC COST	2	\$ 4,613	\$ 4,613	0.87	\$ 4,029	
PERIODIC COST	4	\$ 4,613	\$ 4,613	0.76	\$ 3,519	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	6	\$ 4,613	\$ 4,613	0.67	\$ 3,074	
PERIODIC COST	8	\$ 4,613	\$ 4,613	0.58	\$ 2,685	
PERIODIC COST	10	\$ 19,613	\$ 19,613	0.51	\$ 9,970	
PERIODIC COST	12	\$ 4,613	\$ 4,613	0.44	\$ 2,048	
PERIODIC COST	14	\$ 4,613	\$ 4,613	0.39	\$ 1,789	
PERIODIC COST	15	\$ 20,000	\$ 20,000	0.36	\$ 7,249	
PERIODIC COST	16	\$ 4,613	\$ 4,613	0.34	\$ 1,563	
PERIODIC COST	18	\$ 4,613	\$ 4,613	0.30	\$ 1,365	
PERIODIC COST	20	\$ 19,613	\$ 19,613	0.26	\$ 5,068	
PERIODIC COST	22	\$ 4,613	\$ 4,613	0.23	\$ 1,041	
PERIODIC COST	24	\$ 4,613	\$ 4,613	0.20	\$ 909	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	26	\$ 4,613	\$ 4,613	0.17	\$ 794	
PERIODIC COST	28	\$ 4,613	\$ 4,613	0.15	\$ 694	
PERIODIC COST	30	\$ 911,888	\$ 911,888	0.13	\$ 119,792	
TOTAL PRESENT VALUE OF SOIL					\$ 32,653,512	

Alternative 4 - In Situ Solidification/Stabilization

COST ESTIMATE SUMMARY

GROUNDWATER

OPERATIONS AND MAINTENANCE COST

Inspection of Subaqueous Reactive Barrier (SRB)

Sampling of barrier during low tide	1	LS	\$	15,000	\$	15,000	Excavator onsite for 5 days--expose 5% of barrier every 5 years
Barrier replacement	1	LS	\$	149,250	\$	149,250	25% of barrier every 5 years
SUBTOTAL					\$	164,250	
Allowance for Misc. Items	20%				\$	32,850	
SUBTOTAL					\$	197,100	
Contingency	25%				\$	49,275	10% Scope + 15% Bid
SUBTOTAL					\$	246,375	
Project Management	5%				\$	12,319	
Technical Support	25%				\$	61,594	
SUBTOTAL					\$	73,913	

Contractor Fees

ODC & Subs	5%		\$	246,375	\$	12,319	Calculate as 5% of capital cost
Labor	10%	max	\$	73,913	\$	7,391	Calculate as 10% of labor cost
SUBTOTAL					\$	19,710	

TOTAL FOR SRB O&M

\$ 340,000

Groundwater Monitoring

Groundwater Samples	16	EA	\$	645	\$	10,320	Pesticides, TAL Metals
QC Samples	5	EA	\$	645	\$	3,225	Historical Pricing
Groundwater Sampling, Level D							
Labor	150	HR	\$	80	\$	12,000	CH2M Est. - 3 persons for 5 days
Equipment - meters	1	LS	\$	500	\$	500	CH2M Est.
Consumables	1	LS	\$	200	\$	200	CH2M Est.
Data Validation	24	HR	\$	80	\$	1,920	CH2M Est.
Reporting	50	HR	\$	80	\$	4,000	CH2M Est.
SUBTOTAL					\$	32,165	
Allowance for Misc. Items	20%				\$	6,433	
SUBTOTAL					\$	38,598	
Contingency	25%				\$	9,650	10% Scope + 15% Bid
SUBTOTAL					\$	48,248	
Project Management	5%				\$	2,412	
Technical Support	25%				\$	12,062	
SUBTOTAL					\$	14,474	

Contractor Fees

ODC & Subs	5%		\$	48,248	\$	2,412	Calculate as 5% of capital cost
Labor	10%	max	\$	14,474	\$	1,447	Calculate as 10% of labor cost
SUBTOTAL					\$	3,860	

TOTAL FOR GROUNDWATER SAMPLING EVENT

\$ 66,600

TOTAL ANNUAL O&M COST Year 0 to 2

\$ 266,400 Quarterly for 2 years

TOTAL ANNUAL O&M COST Year 3 to 30

\$ 66,600 Annually

TOTAL ANNUAL O&M COST Year 5, 10, 15, 20, 25, 30

\$ 340,000 Cap maintenance

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 year Review	5	1	LS	\$ 15,000	\$ 15,000	
5 year Review	10	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	10	1	LS	\$ 25,000	\$ 25,000	
5 year Review	15	1	LS	\$ 15,000	\$ 15,000	
5 year Review	20	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	20	1	LS	\$ 25,000	\$ 25,000	
5 year Review	25	1	LS	\$ 15,000	\$ 15,000	
5 year Review	30	1	LS	\$ 15,000	\$ 15,000	
Reapplication for the CEA (Deed)	30	1	LS	\$ 25,000	\$ 25,000	
TOTAL ANNUAL PERIODIC COST					\$ 170,000	

Alternative 4 - In Situ Solidification/Stabilization

COST ESTIMATE SUMMARY

PRESENT VALUE ANALYSIS

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 2,750,000	\$ 2,750,000	1.00	\$ 2,750,000	
ANNUAL O&M COST (Year 0-2)	0 to 2	\$ 532,800	\$ 266,400	1.81	\$ 481,656	
ANNUAL O&M COST (Year 3-30)	3 to 30	\$ 1,864,800	\$ 66,600	10.60	\$ 706,028	
ANNUAL O&M COST (Year 5)	5	\$ 340,000	\$ 340,000	0.71	\$ 242,415	
ANNUAL O&M COST (Year 10)	10	\$ 340,000	\$ 340,000	0.51	\$ 172,839	
ANNUAL O&M COST (Year 15)	15	\$ 340,000	\$ 340,000	0.36	\$ 123,232	
ANNUAL O&M COST (Year 20)	20	\$ 340,000	\$ 340,000	0.26	\$ 87,862	
ANNUAL O&M COST (Year 25)	25	\$ 340,000	\$ 340,000	0.18	\$ 62,645	
ANNUAL O&M COST (Year 30)	30	\$ 340,000	\$ 340,000	0.13	\$ 44,665	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 40,000	\$ 40,000	0.51	\$ 20,334	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 40,000	\$ 40,000	0.26	\$ 10,337	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 40,000	\$ 40,000	0.13	\$ 5,255	
					\$ 4,726,163	

TOTAL PRESENT VALUE FOR GROUNDWATER \$ 4,730,000

Total Present Value for Alternative 4 \$ **37,380,000**

SOURCE INFORMATION

- United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
- a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
- b. R.S. Means Company. 2007. 26th Edition.
- c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
- Historical CH2M HILL project cost information
- Calculations using Historical CH2M HILL project cost information (separate worksheet)

Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT		COST ESTIMATE SUMMARY	
<p>Site: Quanta Resources Site-Edgewater, New Jersey</p> <p>Phase: Preliminary Draft Feasibility Study Report</p> <p>Base Year: 2008</p> <p>Date: 2/10/2008</p>		<p>Description:</p> <ul style="list-style-type: none">-Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils will be excavated to a depth of 4 ft bgs for off-site disposal. NAPL would be collected via 14 recovery wells located in NZ-1 and NZ-5 and two trenches located in NZ-2 near the Hudson River. NAPL collection would be followed by in situ chemical oxidation (ISCO) in NAPL zones NZ-1, NZ-2, and NZ-5. Injection points will be placed adjacent to 115 River Road, but not beneath it.-Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic liner and the liner would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with contamination remaining in place.-Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.-The basements in the 115 River Road building would be converted to crawl spaces with active ventilation. Institutional controls would be established and maintained to control new construction and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and former Lever Brother properties, as needed.-A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established. SHEET PILE AND DISPOSAL OF SEDIMENT ARE NOT INCLUDED IN THIS ESTIMATE.	

CAPITAL COSTS						
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL:						
General Site Work						
Mobilization/Demobilization	5%		\$ 38,700,923	\$ 1,935,046		Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$ 38,700,923	\$ 3,870,092		Calculate as 10% of capital cost
SUBTOTAL				\$ 5,805,138		
Site Establishment						
Survey	200	DY	\$ 1,500	\$ 300,000	CCI Historical	
Fencing	6,000	LF	\$ 15	\$ 90,000	CCI Historical	
Trailer Installation & Setup	1	EA	\$ 3,000	\$ 3,000	CH2M Est.	Tie-downs, stairs, power
Support Area Establishment and Site Offices	24	MO	\$ 4,300	\$ 103,200	CH2M Est.	Includes shed, utilities, lavatories
SUBTOTAL				\$ 496,200		
Institutional Controls (Quanta, 115 River Road, Edgewater, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW, Former Lever Bros)						
Deed Notices (1 for each property)	9	LS	\$ 25,000	\$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
SUBTOTAL				\$ 225,000		
Clearing & Vegetation/Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	\$ 1.28	\$ 3,369	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and Grub Heavy Brush & Trees (includes chipper)	3	AC	\$ 8,203	\$ 24,610	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, assumes 20% of Quanta requires clearing
Tank pad concrete removal & sizing to less than 2 feet	5,645	TON	\$ 128	\$ 720,634	MEANS 02.41.13.17.5500	Concrete demolition, on grade slab, assumes 2' thick concrete pads on 20% of Quanta site, 15% of pads are removed
Asphalt removal	3,969	SY	\$ 3.76	\$ 14,925	Source 3	Assumes 3" thick asphalt to be cleared from 15% of Quanta
Subsurface piping abandonment	1	LS	\$ 250,000	\$ 250,000		Engineer's Estimate
Offsite disposal of cleared materials, concrete (including transportation to < 50 miles)	3,528	CY	\$ 205	\$ 723,316	MEANS 33-19-7270	Assumes HW landfill: Concrete pads + Clearing at 30 CY/AC
Asphalt Disposal	331	CY	\$ 25	\$ 8,275	Source 3	
Dust suppression	20	DY	\$ 820	\$ 16,400	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				\$ 1,761,529		
Site Clearing & Disposal (Block 93, 115 River Road)						
Temporary erosion controls (silt fencing)	2,100	LF	\$ 1.28	\$ 2,696	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	12,578	SY	\$ 3.76	\$ 47,294	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 and 115 River Road
Asphalt Disposal	1,048	CY	\$ 25	\$ 26,200	Source 3	
Dust suppression	5	DY	\$ 820	\$ 4,100	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				\$ 80,290		
Site Clearing & Disposal (Edgewater - Arsenic Area)						
Temporary erosion controls (silt fencing)	1,500	LF	\$ 1.28	\$ 1,926	MEANS 31.25.13.10.1100	Surrounding property boundary
Concrete removal & sizing to less than 2'	6,061	TON	\$ 118	\$ 715,159	MEANS 02.41.13.17.5500	Concrete demolition of access ramp, assumes 2-ft of concrete
Asphalt removal	6,361	SY	\$ 3.76	\$ 23,918	Source 3	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Offsite disposal of concrete (including transportation to < 50 miles)	3,367	CY	\$ 130	\$ 437,715	MEANS 33-19-7270	Assumes non-HW landfill
Asphalt Disposal	530	CY	\$ 25	\$ 13,250	Source 3	
Dust suppression	40	DY	\$ 820	\$ 32,801	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	10	DY	\$ 3,000	\$ 30,000	Source 3	
Excavation, stockpile and backfill of 10-ft of soils above the existing arsenic liner	21,204	CY	\$ 35	\$ 750,473	MEANS 17-03-0276	Assumes material will be replaced following the completion of arsenic stabilization
Temporary Access	1	allow	\$ 65,000	\$ 65,000		
SUBTOTAL				\$ 2,070,241		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	500	LF	\$ 1.28	\$ 642	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	764	SY	\$ 3.76	\$ 2,872	Source 3	Assumes 3" thick asphalt to be cleared
Asphalt Disposal	64	CY	\$ 25	\$ 1,600	Source 3	
Dust suppression	7	DY	\$ 820	\$ 5,740	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig Permits & Utility Markout	1	DY	\$ 3,000	\$ 3,000	Source 3	
SUBTOTAL				\$ 13,854		
Excavation, Backfilling, & Soil Disposal						
Excavation of Tar Boils & Soils Containing Tars (Quanta property)						
Dig Permits & Utility Markout	3	DAY	\$ 3,000	\$ 9,000	Source 3	
Excavation of Contaminated soil (from tar boils & containing soft, plastic, or hard tars)	31,243	CY	\$ 30	\$ 927,923	MEANS 17-03-0276	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	37,492	CY	\$ 18	\$ 663,698	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	12	DY	\$ 820	\$ 9,840	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
On-site stabilization of excavated contaminated soils with Portland Cement	61,862	TON	\$ 35	\$ 2,165,154	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 Tons/CY
Disposal of stabilized contaminated soil removed (from tar boils & containing soft, plastic, or hard tars) - Non-Haz Waste	35,570	CY	\$ 130	\$ 4,624,150	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in weight from add'l material, 2.0 Tons/CY)
Confirmation Sampling	62	EA	\$ 200	\$ 12,400	CH2M Est.	
Data Validation	40	HR	\$ 90	\$ 3,600	CH2M Est.	
Shoring around buildings	2,263	LF	\$ 62	\$ 1,122,448		Assumes sheet pile will be driven 8 feet bgs
SUBTOTAL				\$ 9,538,273		

Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT

COST ESTIMATE SUMMARY

In-Situ Treatment

Preconstruction Investigations									
Pilot-Scale Testing	1	LS	\$	250,000	\$	250,000	CH2M HILL Est.		
In-Situ Chemical Oxidation								Pilot testing excluded from estimate	
ISCO Application (vendor costs) - Quanta Site (based on vendor estimate of 6,000 CY at SS2 sample contaminant level)	1	LS	\$	5,926,844	\$	5,926,844		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL. Assumed that this covers all applications as required	
ISCO Application (vendor costs) - Edgewater Site (based on vendor estimate of 1,000 CY at SS2 sample contaminant level)	1	LS	\$	1,318,919	\$	1,318,919		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL. Assumed that this covers all applications as required	
ISCO Application (vendor costs) - 115 River Rd Site (based on vendor estimate of 6,000 CY at SS2 sample contaminant level)	1	LS	\$	5,926,844	\$	5,926,844		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL. Assumed that this covers all applications as required	
ISCO Application (vendor costs) - Former Lever Brothers Site (based on vendor estimate of 2,700 CY at SS2 sample contaminant level)	1	LS	\$	2,680,872	\$	2,680,872		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL. Assumed that this covers all applications as required	
Post-Application Performance Monitoring (assume 1 set of samples per property)	5	LS	\$	4,613	\$	23,065	Source 4	Same monitoring as for MNA: VOCs, SVOCs, PCBs, TAL metals	
SUBTOTAL					\$	16,126,544			
In-Situ Stabilization (Arsenic Materials > 336 mg/kg) (Quanta and Block 93 North)									
Set-up Fee	1	LS	\$	40,000	\$	40,000	CH2M HILL Est.		
Jet Grout around Utilities	300	LF	\$	35	\$	10,500	CH2M HILL Est.		
Reagent at 5% Additive - Ferrous Sulfate	22,441	CY	\$	22	\$	486,970	Source 3		
Reagent at 15% Additive - Cement	22,441	CY	\$	30	\$	666,498	Source 3		
In-Situ Mixing	22,441	CY	\$	30	\$	673,230	Vendor		
Tear-Down/Decon	1	LS	\$	2,500	\$	2,500	Source 3	Assume mixing with 8-ft mixing auger	
SUBTOTAL					\$	1,879,697			
In-Situ Stabilization (Arsenic Materials > 336 mg/kg) (Edgewater)									
Set-up Fee	1	LS	\$	40,000	\$	40,000	CH2M HILL Est.		
Jet Grout around Utilities	1,200	LF	\$	35	\$	42,000	CH2M HILL Est.		
Reagent at 5% Additive - Ferrous Sulfate	16,835	CY	\$	22	\$	365,320	Source 3		
Reagent at 15% Additive - Cement	16,835	CY	\$	30	\$	500,000	Source 3		
In-Situ Mixing	16,835	CY	\$	30	\$	505,050	Vendor		
Tear-Down/Decon	1	LS	\$	2,500	\$	2,500	Source 3	Assume mixing with 8-ft mixing auger	
SUBTOTAL					\$	1,454,869			
Capping									
New Engineered Impermeable Cap (115 River Road, Block 93)								Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above	
Rough site grading	27,875	SY	\$	5.15	\$	143,433	MEANS 17-03-0101	Assume no fill needed for grading	
Fine grading	27,875	SY	\$	1.42	\$	39,629	MEANS 17-03-0101	Assume no fill needed for grading	
Gravel Base, 6 inches	4,646	CY	\$	53.47	\$	248,441	MEANS 32.11.23.23.1511		
Dust suppression	32	DY	\$	820	\$	26,240	MEANS 31.23.23.18.4500	Concurrent site activities/dust control	
Storm water control (3' x 3' culverts, rip-rap)	8	EA	\$	11,638	\$	93,101	Source 4	Included 2 storm water control systems per capped property	
Asphalt stabilized binder course, 2" thick	27,875	SY	\$	22.89	\$	638,031	MEANS 32.12.16.13.0120		
Asphalt wear course, 2" thick	27,875	SY	\$	23.43	\$	653,153	MEANS 32.12.16.13.0380		
Install Asphalt Curb/Berm on Perimeter	4,300	LF	\$	11.04	\$	47,472	MEANS 32.16.19.10.0150		
SUBTOTAL					\$	1,889,502			
Replacement of Access Ramp and Parking Lots (Edgewater)								Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above	
Backfilling and compaction of excavated material	21,204	CY	\$	18	\$	375,358	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction	
Rough site grading	8,275	SY	\$	5.15	\$	42,580	MEANS 17-03-0101	Assume no fill needed for grading	
Fine grading	8,275	SY	\$	1.42	\$	11,764	MEANS 17-03-0101	Assume no fill needed for grading	
Gravel Base, 6 inches	1,379	CY	\$	53	\$	73,741	MEANS 32.11.23.23.1511		
Dust suppression	60	DY	\$	820	\$	49,201	MEANS 31.23.23.18.4500	Concurrent site activities/dust control	
Storm water control (3' x 3' culverts, rip-rap)	2	EA	\$	11,638	\$	23,275	Source 4	Included 2 storm water control systems per capped property	
Asphalt stabilized binder course, 2" thick	8,275	SY	\$	23	\$	189,407	MEANS 32.12.16.13.0120		
Asphalt wear course, 2" thick	8,275	SY	\$	23	\$	193,896	MEANS 32.12.16.13.0380		
Install Asphalt Curb/Berm on Perimeter	2,500	LF	\$	11	\$	27,600	MEANS 32.16.19.10.0150		
SUBTOTAL					\$	986,821			
New Cap (115 River Road Property - Basement Area)								Assumption: 1 ton of mtrl & equip/250sf (15.81' x 15.81')	
Clear & disposal of basement materials (equipment, etc.)	16,722	SF	\$	0.43	\$	7,239	MEANS 02.41.19.19.0300		
Abandon/Demo Basement Facility Trench Drains (trenching, concrete, grating)	1,700	LF	\$	68	\$	115,600	MEANS 22.14.26.19.6650		
Disposal of Basement Demo Material	1	LS	\$	10,000	\$	10,000	Estimator Judgement		
Install HDPE liner	1,858	SF	\$	15	\$	28,669	MEANS 02.660.610.1200		
Fill Basement with 2 feet of Fill	1,239	CY	\$	53	\$	66,237	MEANS 32.11.23.23.1511		
Fill Basement with 2 feet of Concrete	1,239	CY	\$	206	\$	255,374	MEANS 03.31.05.70.4300	Normal weight concrete and placement	
Insulation	16,722	SF	\$	2	\$	33,444			
SUBTOTAL					\$	516,563			
New Vegetative Cap (Assumes 50% of the Property will include a Engineering Cap with Drainage Layer)								Silt fence around Quanta property included under engineered cap	
Rough grading	24,774	SY	\$	5.15	\$	127,478	MEANS 17-03-0101		
Fine grading	24,774	SY	\$	1.42	\$	35,221	MEANS 17-03-0101		
Protective layer, 12" compacted soil subgrade	8,258	CY	\$	18	\$	146,188	MEANS 17-03-0423		
HDPE Liner, 40 mil thick	12,387	SY	\$	15	\$	191,133	ECHOS 33.08.0572		
Drainage layer, 6" granular soil (assume gravel)	2,065	CY	\$	53	\$	110,399	MEANS 32.11.23.23.1511		
Grade, Place Geotextile filter fabric	24,774	SY	\$	2.00	\$	49,548	Source 3		
Vegetative layer, 18" soil	12,387	CY	\$	18	\$	219,282	MEANS 17-03-0423		
Top soil, 6"	4,129	CY	\$	30	\$	123,871	MEANS 31.05.13.10.0800		
Dust suppression	45	DY	\$	820	\$	36,901	MEANS 31.23.23.18.4500	Concurrent site activities/dust control	
Hydroseed	222,968	SF	\$	0.07	\$	15,608	Source 3		
Watering	223	MSF	\$	56	\$	12,452	MEANS 32.01.09.26.4900	Based on 1" of water per 1,000 sf, 4 -watering events (.25-in per event)	
SUBTOTAL					\$	1,068,081			

Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT					COST ESTIMATE SUMMARY		
Compliance Monitoring and Health & Safety							
Environmental Controls	1	LS	\$	12,772	\$	12,772	Source 4
Analytical Requirements - Disposal	708	EA	\$	2.6	\$	1,841	Vendor
							Based on total materials to be disposed
							Assumed 1 strength test for every 400 cy of material mixed
Analytical Requirements - In Situ Solidification/Stabilization	98	EA	\$	25	\$	2,455	Vendor
Install Decon Shed for workers (Mobilization & Demobilization)	1	LS	\$	500	\$	500	Source 3
Decon Shed	24	MO	\$	1,043	\$	25,021	Source 4
Air Monitoring	383	DY	\$	718	\$	274,803	Source 4 + CH2M H&S
PPE Provisions for Workers (Initial)	30	EA	\$	252	\$	7,557	Source 4
PPE Provisions for Workers (Worker Days)	12672	EA	\$	21	\$	268,569	Source 4 + CH2M H&S
SUBTOTAL					\$	593,518	10 labor, 4 operator, 4 trucks, 2 supervisor 24 months*22days *20 workers
CAPITAL SUBTOTAL - SOIL				All Tasks	\$	44,756,061	
Contingency	25%				\$	11,189,015	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11
SUBTOTAL					\$	55,945,077	
Project Management				5%	\$	2,797,254	USEPA 2000, p. 5-13, >\$10M
Remedial Design				6%	\$	3,356,705	USEPA 2000, p. 5-13, >\$10M
Construction Management				6%	\$	3,356,705	USEPA 2000, p. 5-13, > \$10M
SUBTOTAL					\$	9,510,663	
Contractor Fees							
ODC & Subs	5%		\$	55,945,077	\$	2,797,254	Calculate as 5% of capital cost
Labor	10%	max	\$	9,510,663	\$	951,066	Calculate as 10% of labor cost
SUBTOTAL - SOILS					\$	3,748,320	
TOTAL CAPITAL COST - SOIL					\$	69,204,060	

NAPL							
General							
Mobilization/Demobilization	5%		\$	1,953,044	\$	97,652	Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$	1,953,044	\$	195,304	Calculate as 10% of capital cost
SUBTOTAL					\$	292,957	
NAPL Recovery Trenches							
Preconstruction Investigations							
Slurry compatibility test	1	LS	\$	25,000	\$	25,000	CH2M Est.
Pumping Test	1	LS	\$	75,000	\$	75,000	CH2M Est.
Pilot Field Test	1	LS	\$	100,000	\$	100,000	CH2M Est., assumed design of test is included in design line item (@ 8%)
Utility Markout / Locating Service	3	LS	\$	3,000	\$	9,000	
SUBTOTAL					\$	209,000	
Recovery Trench Installation							
On-Site Slurry Mixing Plant	1	LS	\$	144,000	\$	144,000	Assumed asphalt, concrete removal, site clearing is covered under soil remediation
Biopolymer Slurry (trench stabilization)	155,000	GAL	\$	0.06	\$	9,300	Estimator Judgment
Trenching, for Recovery System	767	CY	\$	15	\$	11,505	Based on total trench volume, ECHOS
Trench Backfill / Placement with Tremie Pipe	763	CY	\$	1.83	\$	1,396	MEANS
Gravel, dumped and delivered	763	CY	\$	35	\$	26,361	MEANS, Backfill with gravel
Geosynthetic Clay Liner	230	SF	\$	3.02	\$	696	MEANS
Backfill with clean soil to grade	4	CY	\$	19	\$	76	Assume Claymax 200R or equivalent, Source 3
Precast Concrete Sump (4'x4'x4') w/Aluminum manhole for well access	2	EA	\$	4,000	\$	8,000	
Trench development	1	LS	\$	10,350	\$	10,350	Estimator Judgment
24" SS Extraction Wells w/ Sumps	62	LF	\$	250	\$	15,500	Estimators Judgment
Product Recovery Pumps	2	EA	\$	4,000	\$	8,000	Source 3
SUBTOTAL					\$	235,185	Positive displacement piston pump, 1HP motor, 0-7 GPM
Install Equipment & Utilities for NAPL Collection/Handling							
Utility Trenching	1,153	CY	\$	7.04	\$	8,122	4 ft Deep, Includes Piping & Power Distribution, Source 3
Electrical Conduit	3,040	LF	\$	1.68	\$	5,099	Assume power & controls wiring run in separate conduit, MEANS 260-533.10
Backfill to grade	1,153	CY	\$	19.09	\$	22,017	Source 3
NAPL Recovery Piping (Double walled)	1,075	LF	\$	50	\$	53,750	Assume 2" piping, material of construction
Freeze Protection for Recovery Piping	1,075	LF	\$	3	\$	3,225	Heat trace
Control System & Wiring (includes panels)	1	EA	\$	25,000	\$	25,000	Includes remote access & autodialer
Control Wiring	2	EA	\$	800	\$	1,600	
Power Supply to the Site	1	LS	\$	16,000	\$	16,000	Includes distribution gear, disconnects to tie-in to central utility, Estimators
Power Wiring, #10 Insulated Strand Wire	3,040	LF	\$	0.59	\$	1,794	
Electrical Disconnect, weatherhead, and installation of wiring	2	EA	\$	5,000.00	\$	10,000	Pumps are 1 HP, 230V or 460V, 3 Phase, Estimators Judgment
Concrete Pad	1	LS	\$	25,000	\$	25,000	CH2M Est.
Plumbing, Fire Suppression	1	LS	\$	10,000	\$	10,000	CH2M Est.
Utility Connections	1	LS	\$	10,000	\$	10,000	CH2M Est.
Permits	1	LS	\$	1,500	\$	1,500	CH2M Est.
Storage Tanks, 200 gallon	1	EA	\$	4,970	\$	4,970	HDPE Tanks with ports for inlet / vent / level / outlet, Baliff Enterprises price
Spare Product Recovery Pumps	2	EA	\$	4,000	\$	8,000</	

Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT

COST ESTIMATE SUMMARY

Recovery Well Installation

Soil Borings, 24" Diameter	210	LF	\$	300	\$	63,000	Air rotary rig and crew, wells are 15' deep, 14 wells
8-inch SS Well Casing	210	LF	\$	197	\$	41,280	Casing along full length of well (15' deep), 14 wells, ECHOS
8-inch SS Well Screen	154	LF	\$	197	\$	30,338	Well is screened from 4' bgs to bottom of well, 14 wells
8-inch SS Well Riser	56	LF	\$	197	\$	11,032	4' of well riser, 14 wells
Sand / Bentonite Materials	14	EA	\$	400	\$	5,600	Source 3
Backfill borings, pea gravel	13	CY	\$	35	\$	449	Source 3
Well development	14	EA	\$	1,600	\$	22,400	Source 3
Product Recovery Pumps	7	EA	\$	4,000	\$	28,000	Positive displacement piston pump, 1HP motor, 0-7 GPM, vendor budgetary quote
Roadboxes (for sump / well access)	7	EA	\$	2,500	\$	17,500	Assume asphalt cap under soil remediation costing ties into roadboxes
SUBTOTAL					\$	219,599	

Install Equipment & Utilities for NAPL Collection/Handling

Utility Trenching	133	CY	\$	11	\$	1,467	4 ft Deep, Includes Piping & Power Distribution, Source 3
Electrical Conduit	600	LF	\$	8.00	\$	4,800	ECHOS 20.02.0610
Backfill to grade	160	CY	\$	19	\$	3,054	Use 1.2X compaction factor
Control Wiring	7	EA	\$	500	\$	3,500	
Power Supply to the Site	1	LS	\$	16,000	\$	16,000	Includes gear/disconnects to tie-in to central utility, Estimators Judgment
Power Wiring, #10 Insulated Strand Wire	600	LF	\$	0.59	\$	354	Source 3
Electrical Disconnect, weatherhead, and installation of wiring	7	EA	\$	5,000	\$	35,000	Pumps are 1 HP, 230V or 460V, 3 Phase, Estimators Judgment
Spare Product Recovery Pumps	2	EA	\$	4,000	\$	8,000	Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					\$	72,175	

Offsite Treatment / Disposal

On-Site Waste Management - Soil	146	CY	\$	7.00	\$	1,024	Transfer to drums for disposal
Off-site Disposal of Soil	146	CY	\$	205	\$	29,998	Include soils from Recovery Well installation & trenching, assume sent to HW landfill
Off-site Disposal of Municipal Waste	240	CY	\$	130	\$	31,200	Assume 2 rollofs per month
Off-site Disposal of NAPL (well development)	5	GAL	\$	2.00	\$	10	Source 3
SUBTOTAL					\$	62,233	

System Startup

	1	LS	\$	50,000	\$	50,000	Estimators Judgment
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Compliance Monitoring and Health & Safety

Environmental Controls	1	LS	\$	11,577	\$	11,577	Source 4
Analytical Requirements for Disposal	146	CY	\$	2.60	\$	380	Source 3
Install Decon Shed for workers	1	LS	\$	1,043	\$	1,043	Source 4
Decon Shed	4	MO	\$	1,043	\$	4,170	Source 4
Air Monitoring	16	DY	\$	718	\$	11,480	Source 4 + CH2M H&S
PPE Provisions for Workers (Initial)	15	EA	\$	252	\$	3,778	Source 4
PPE Provisions for Workers (Worker-Days)	1,320	EA	\$	21	\$	27,976	Source 4 + CH2M H&S
SUBTOTAL					\$	60,404	

CAPITAL SUBTOTAL - NAPL

Contingency	25%				\$	2,246,000	
SUBTOTAL					\$	561,500	10% Scope + 15% Bid

Project Management	5%				\$	140,375	USEPA 2000, p. 5-13, \$2M - \$10M
Remedial Design	8%				\$	224,600	USEPA 2000, p. 5-13, \$2M - \$10M
Construction Management	6%				\$	168,450	USEPA 2000, p. 5-13, \$2M - \$10M
SUBTOTAL					\$	533,425	

Contractor Fees

ODC & Subs	5%			\$	2,807,501	\$	140,375	Calculate as 5% of capital cost
Labor	10%	max		\$	533,425	\$	53,343	Calculate as 10% of labor cost
SUBTOTAL						\$	193,718	

TOTAL CAPITAL COST - NAPL	\$	3,530,000
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GROUNDWATER

General

Mobilization/Demobilization	5%			\$	1,464,000	\$	73,200	Calculate as 5% of capital cost
Subcontractor General Conditions	10%			\$	1,464,000	\$	146,400	Calculate as 10% of capital cost
SUBTOTAL						\$	219,600	

Replacement Monitoring Wells

Soil Borings	480	FT	\$	47	\$	22,320	Assumes 16 wells at 30-ft deep
2-inch PVC Well Casing	480	FT	\$	15	\$	7,109	
2-inch PVC Well Screen	160	FT	\$	25	\$	4,003	Assumes 10-ft screen
2-inch PVC Riser	320	FT	\$	15	\$	4,739	
Well cuttings disposal	16	EA	\$	100	\$	1,600	Assumes one 55-gal drum per well
Well development	16	EA	\$	1,600	\$	25,600	
SUBTOTAL					\$	65,371	

Site Preparation

Erosion Control	1	LS	\$	20,000	\$	20,000	
Permitting	1	LS	\$	150,000	\$	150,000	
Survey (pre and post installation)	2	EA	\$	2,500	\$	5,000	
Staging Pad	1	LS	\$	10,000	\$	10,000	
Rental and operation of generator	1	MO	\$	17,050	\$	17,050	
Rental of frac tank	1	MO	\$	500	\$	500	\$150/dy rent + \$400/dy fuel = \$550/dy
Portadam® Barriers - Setup, teardown, and one month rental	1,200	LF	\$	100	\$	120,000	
Portadam® Barriers - Additional rental	2	WK	\$	15,600	\$	31,200	
Cut-Off Timber Piles Allowance	1	LS	\$	150,000	\$	150,000	
SUBTOTAL					\$	503,750	

Excavate 2' of Impacted Sediment

Pump out area within Portadams®	30	DY	\$	1,275	\$	38,250	Source 3
Pump fuel and oil	1,500	GAL	\$	4	\$	6,000	Source 3
Excavate 2' sediment from dewatered area	11,000	CY	\$	25	\$	275,000	Source 3
Transportation of material back to staging pad	11,000	CY	\$	4	\$	44,000	Source 3
SUBTOTAL					\$	363,250	750 GPM Godwin Dri-Prime 6" Model CD150M 3.1 GPH Diesel Fuel x 24 hrs/day x 20 days Assumed area 160' x 950'

Install RCM Mat & Armor Layer

Organoclay RCM material	120	ROLL	\$	3,000	\$	360,000	Source 3
Install organoclay RCM	150,000	SF	\$	1	\$	75,000	Source 3
12" sand armor layer (material only)	6,000	CY	\$	20	\$	120,000	Source 3
Install 12" sand armor layer	6,000	CY	\$	7	\$	42,000	Source 3
SUBTOTAL					\$	597,000	20% extra for overlap - 1,500 ft2/roll x \$2.00/ft2

CAPITAL SUBTOTAL - Groundwater

Contingency	25%				\$	1,748,971	
SUBTOTAL					\$	437,243	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11

Project Management	5%				\$	109,311	USEPA 2000, p. 5-13, \$500K-\$2M
Remedial Design	8%				\$	174,897	USEPA 2000, p. 5-13, \$500K-\$2M
Construction Management	6%				\$	131,173	USEPA 2000, p. 5-13, \$500K-\$2M
SUBTOTAL					\$	415,381	

Contractor Fees

ODC & Subs	5%			\$	2,186,213	\$	109,311	Calculate as 5% of capital cost
Labor	10%	max		\$	415,381	\$	41,538	Calculate as 10% of labor cost
SUBTOTAL						\$	150,849	

TOTAL CAPITAL COST - GROUND WATER	\$	2,750,000
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Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT					COST ESTIMATE SUMMARY		
SOIL							
OPERATIONS AND MAINTENANCE COST							
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES		
Cap Maintenance							
Cap Repair	1	LS	\$ 16,745	\$ 16,745	Biennial Report to NJDEP	Assumes 1% of area requires repair annually, cap costs are based on repaving and maintaining the soil cap at Quanta	
Cap Inspection and Repair Report	1	LS	\$ 2,000	\$ 2,000			
Fan System Maintenance (115 River Road)	8	HR	\$ 80	\$ 640			
SUBTOTAL				\$ 19,385			
Contingency	25%			\$ 4,846	10% Scope + 15% Bid		
SUBTOTAL				\$ 24,231			
Project Management	5%			\$ 1,212			
Technical Support	25%			\$ 6,058			
SUBTOTAL				\$ 7,269			
Contractor Fees							
ODC & Subs	5%		\$ 24,231	\$ 1,212	Calculate as 5% of capital cost		
Labor	10%	max	\$ 7,269	\$ 727	Calculate as 10% of labor cost		
SUBTOTAL				\$ 1,938			
TOTAL ANNUAL O&M COST - Soil (Year 1 to 30)				\$ 33,400			
PERIODIC COSTS							
DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES	
2 Year Biennial Certification	2	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	4	1	LS	\$ 4,613	\$ 4,613		
5 year Review	5	1	LS	\$ 15,000	\$ 15,000		
2 Year Biennial Certification	6	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	8	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	10	1	LS	\$ 4,613	\$ 4,613		
5 year Review	10	1	LS	\$ 15,000	\$ 15,000		
2 Year Biennial Certification	12	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	14	1	LS	\$ 4,613	\$ 4,613		
5 year Review	15	1	LS	\$ 15,000	\$ 15,000		
Replace Fans in 115 River Road	15	1	LS	\$ 5,000	\$ 5,000		
2 Year Biennial Certification	16	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	18	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	20	1	LS	\$ 4,613	\$ 4,613		
5 year Review	20	1	LS	\$ 15,000	\$ 15,000		
2 Year Biennial Certification	22	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	24	1	LS	\$ 4,613	\$ 4,613		
5 year Review	25	1	LS	\$ 15,000	\$ 15,000		
2 Year Biennial Certification	26	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	28	1	LS	\$ 4,613	\$ 4,613		
2 Year Biennial Certification	30	1	LS	\$ 4,613	\$ 4,613		
5 year Review	30	1	LS	\$ 15,000	\$ 15,000		
Replace Fans in 115 River Road	30	1	LS	\$ 5,000	\$ 5,000		
Asphalt Cap Replacement	30	1	LS	\$ 887,275	\$ 887,275	Assume complete replacement of 30% of cap after 30 years	
TOTAL ANNUAL PERIODIC COST				\$ 1,060,000			
PRESENT VALUE ANALYSIS				Discount Rate = 7.0%	Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.		
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES	
CAPITAL COST	0	\$ 69,204,060	\$ 69,204,060	1.00	\$ 69,204,060		
ANNUAL O&M COST - Cap	1 to 30	\$ 1,002,000	\$ 33,400	12.41	\$ 414,462		
PERIODIC COST	2	\$ 4,613	\$ 4,613	0.87	\$ 4,029		
PERIODIC COST	4	\$ 4,613	\$ 4,613	0.76	\$ 3,519		
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695		
PERIODIC COST	6	\$ 4,613	\$ 4,613	0.67	\$ 3,074		
PERIODIC COST	8	\$ 4,613	\$ 4,613	0.58	\$ 2,685		
PERIODIC COST	10	\$ 19,613	\$ 19,613	0.51	\$ 9,970		
PERIODIC COST	12	\$ 4,613	\$ 4,613	0.44	\$ 2,048		
PERIODIC COST	14	\$ 4,613	\$ 4,613	0.39	\$ 1,789		
PERIODIC COST	15	\$ 20,000	\$ 20,000	0.36	\$ 7,249		
PERIODIC COST	16	\$ 4,613	\$ 4,613	0.34	\$ 1,563		
PERIODIC COST	18	\$ 4,613	\$ 4,613	0.30	\$ 1,365		
PERIODIC COST	20	\$ 19,613	\$ 19,613	0.26	\$ 5,068		
PERIODIC COST	22	\$ 4,613	\$ 4,613	0.23	\$ 1,041		
PERIODIC COST	24	\$ 4,613	\$ 4,613	0.20	\$ 909		
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764		
PERIODIC COST	26	\$ 4,613	\$ 4,613	0.17	\$ 794		
PERIODIC COST	28	\$ 4,613	\$ 4,613	0.15	\$ 694		
PERIODIC COST	30	\$ 911,888	\$ 911,888	0.13	\$ 119,792		
					\$ 69,797,571		
TOTAL PRESENT VALUE FOR SOIL					\$ 69,800,000		
NAPL							
NAPL Recovery							
Electricity - Pump Operation (1.5 HP pump)	7	EA	\$ 1,618	\$ 11,329	MEANS 33-42-0102		
Misc. Electrical Site Usage	12	MO	\$ 3,660	\$ 43,924	MEANS 33-42-0106		
Routine Operations, Maintenance, Monitoring	600	HR	\$ 80	\$ 48,000	Assumes part time operator performs duties for NAPL system (5 days/month)		
Parts Replacement / Consumables	1	LS	\$ 5,000	\$ 5,000			
O&M Project Management	1	LS	\$ 7,200	\$ 7,200	15% of O&M		
Electricity	12	MO	\$ 1,500	\$ 18,000	MEANS 33-42-0106		
Reporting	1	LS	\$ 20,000	\$ 20,000	CH2M Est.		
Pumping & Transport of NAPL (Vac Truck)	1,000	GAL	\$ 1.00	\$ 1,000	Assume each truck 1000 gallons		
Off-site Disposal of NAPL	2,000	GAL	\$ 2.00	\$ 4,000	</		

Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT					COST ESTIMATE SUMMARY		
PERIODIC COSTS							
DESCRIPTION		QTY	UNIT	UNIT COST	TOTAL		NOTES
5 year Review		5	1	LS	\$	15,000	\$ 15,000
5 year Review		10	1	LS	\$	15,000	\$ 15,000 Assumes NAPL recovery will be completed after 10 years
SUBTOTAL							\$ 30,000
TOTAL ANNUAL PERIODIC COST						\$	30,000
PRESENT VALUE ANALYSIS							
		Discount Rate =		7.0%			
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE		NOTES
CAPITAL COST	0	\$ 3,530,000	\$ 3,530,000	1.00	\$	3,530,000	
ANNUAL O&M COST	1 to 10	\$ 2,700,000	\$ 270,000	7.02	\$	1,896,367	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$	10,695	
PERIODIC COST	10	\$ 15,000	\$ 15,000	1.00	\$	15,000	
						\$ 5,452,062	
TOTAL PRESENT VALUE OF NAPL						\$	5,450,000
GROUNDWATER							
OPERATIONS AND MAINTENANCE COST							
Inspection of Subaqueous Reactive Barrier (SRB)							
Sampling of barrier during low tide		1	LS	\$	15,000	\$ 15,000	Excavator onsite for 5 days--expose 5% of barrier every 5 years
Barrier replacement		1	LS	\$	149,250	\$ 149,250	25% of barrier every 5 years
SUBTOTAL						\$ 164,250	
Allowance for Misc. Items		20%				\$ 32,850	
SUBTOTAL						\$ 197,100	
Contingency		25%				\$ 49,275	10% Scope + 15% Bid
SUBTOTAL						\$ 246,375	
Project Management		5%				\$ 12,319	
Technical Support		25%				\$ 61,594	
						\$ 73,913	
Contractor Fees							
ODC & Subs		5%		\$	246,375	\$ 12,319	Calculate as 5% of capital cost
Labor		10%	max	\$	73,913	\$ 7,391	Calculate as 10% of labor cost
SUBTOTAL						\$ 19,710	
TOTAL FOR SRB O&M						\$	340,000
Groundwater Monitoring							
Groundwater Samples		16	EA	\$	645	\$ 10,320	Pesticides, TAL Metals
QC Samples		5	EA	\$	645	\$ 3,225	Historical Pricing
Groundwater Sampling, Level D							
Labor		150	HR	\$	80	\$ 12,000	CH2M Est. - 3 persons for 5 days
Equipment - meters		1	LS	\$	500	\$ 500	CH2M Est.
Consumables		1	LS	\$	200	\$ 200	CH2M Est.
Data Validation		24	HR	\$	80	\$ 1,920	CH2M Est.
Reporting		50	HR	\$	80	\$ 4,000	CH2M Est.
SUBTOTAL						\$ 32,165	
Allowance for Misc. Items		20%				\$ 6,433	
SUBTOTAL						\$ 38,598	
Contingency		25%				\$ 9,650	10% Scope + 15% Bid
SUBTOTAL						\$ 48,248	
Project Management		5%				\$ 2,412	
Technical Support		25%				\$ 12,062	
						\$ 14,474	
Contractor Fees							
ODC & Subs		5%		\$	48,248	\$ 2,412	Calculate as 5% of capital cost
Labor		10%	max	\$	14,474	\$ 1,447	Calculate as 10% of labor cost
SUBTOTAL						\$ 3,860	
TOTAL FOR GROUNDWATER SAMPLING EVENT						\$	66,600
TOTAL ANNUAL O&M COST Year 0 to 2						\$	266,400 Quarterly for 2 years
TOTAL ANNUAL O&M COST Year 3 to 30						\$	66,600 Annually
TOTAL ANNUAL O&M COST Year 5, 10, 15, 20, 25, 30						\$	340,000 Cap maintenance
PERIODIC COSTS							
DESCRIPTION		YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 year Review		5	1	LS	\$	15,000	\$ 15,000
5 year Review		10	1	LS	\$	15,000	\$ 15,000
Reapplication for the CEA (Deed)		10	1	LS	\$	25,000	\$ 25,000
5 year Review		15	1	LS	\$	15,000	\$ 15,000
5 year Review		20	1	LS	\$	15,000	\$ 15,000
Reapplication for the CEA (Deed)		20	1	LS	\$	25,000	\$ 25,000
5 year Review		25	1	LS	\$	15,000	\$ 15,000
5 year Review		30	1	LS	\$	15,000	\$ 15,000
Reapplication for the CEA (Deed)		30	1	LS	\$	25,000	\$ 25,000
						\$ 165,000	
TOTAL ANNUAL PERIODIC COST						\$	170,000

Alternative 5: In Situ Solidification/Stabilization and Other In Situ Treatment - DRAFT					COST ESTIMATE SUMMARY	
PRESENT VALUE ANALYSIS			Discount Rate = 7.0%			
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 2,750,000	\$ 2,750,000	1.00	\$ 2,750,000	
ANNUAL O&M COST (Year 0-2)	0 to 2	\$ 532,800	\$ 266,400	1.81	\$ 481,656	
ANNUAL O&M COST (Year 3-30)	3 to 30	\$ 1,864,800	\$ 66,600	10.60	\$ 706,028	
ANNUAL O&M COST (Year 5)	5	\$ 340,000	\$ 340,000	0.71	\$ 242,415	
ANNUAL O&M COST (Year 10)	10	\$ 340,000	\$ 340,000	0.51	\$ 172,839	
ANNUAL O&M COST (Year 15)	15	\$ 340,000	\$ 340,000	0.36	\$ 123,232	
ANNUAL O&M COST (Year 20)	20	\$ 340,000	\$ 340,000	0.26	\$ 87,862	
ANNUAL O&M COST (Year 25)	25	\$ 340,000	\$ 340,000	0.18	\$ 62,645	
ANNUAL O&M COST (Year 30)	30	\$ 340,000	\$ 340,000	0.13	\$ 44,665	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 40,000	\$ 40,000	0.51	\$ 20,334	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 40,000	\$ 40,000	0.26	\$ 10,337	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 40,000	\$ 40,000	0.13	\$ 5,255	
					\$ 4,726,163	
TOTAL PRESENT VALUE FOR GROUNDWATER					\$ 4,730,000	
Total Present Value for Alternative 5			\$	79,980,000		
SOURCE INFORMATION						
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).						
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)						
2b. R.S. Means Company. 2007. 26th Edition.						
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.						
3. Historical CH2M HILL project cost information						
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)						

Alternative 6: Excavation - DRAFT			COST ESTIMATE SUMMARY				
Site: Quanta Resources Site-Edgewater, New Jersey		Description:					
Phase: Preliminary Draft Feasibility Study Report		<p>-NAPL zones (NZ-1, NZ-2, and NZ-5) and tar boils would be excavated and disposed of off-site. Excavation would require dewatering to achieve depths greater than 4 feet. Following excavation the site would be filled with clean material to grade. NAPL would be separated from the water generated from dewatering activities. NAPL would be disposed of off-site and water would be treated on site prior to discharge to the Hudson River.</p> <p>-Areas with arsenic concentrations greater than 336 ppm would be stabilized/solidified in situ. Fill material above the existing arsenic cap would be removed, to the extent practicable and stored for reuse. Institutional controls would be established and maintained to document and limit use of areas with contamination remaining in place.</p> <p>-Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, Block 93 (north, central, and south), and portions of 115 River Road. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.</p> <p>-The basements in the 115 River Road building would be converted to crawl spaces with active ventilation. Institutional controls would be established and maintained to control new construction and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the occupied buildings at Block 93 and former Lever Brother properties, as needed.</p> <p>-A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2. Institutional controls restricting groundwater use would be established. SHEET PILE AND DISPOSAL OF SEDIMENT ARE NOT INCLUDED IN THIS ESTIMATE.</p>					
Base Year: 2008							
Date: 2/10/2008							
CAPITAL COSTS							
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS	
SOIL:							
General Site Work							
Mobilization/Demobilization	5%		\$	51,192,764	\$	2,559,638	Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$	51,192,764	\$	5,119,276	Calculate as 10% of capital cost
SUBTOTAL					\$	7,678,915	
Site Establishment							
Survey	200	DY	\$	1,500	\$	300,000	CCI Historical
Fencing	6000	LF	\$	15	\$	90,000	CCI Historical
Trailer Installation & Setup	1	EA	\$	3,000	\$	3,000	CH2M Est.
Support Area Establishment and Site Offices	24	MO	\$	4,300	\$	103,200	CH2M Est.
SUBTOTAL					\$	496,200	Tie-downs, stairs, power Includes shed, utilities, lavatories
Institutional Controls (Quanta, 115 River Road, Edgewater, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW, Former Lever Bros)							
Deed Notices (1 for each property)	9	LS	\$	25,000	\$	225,000	CH2M Est.
SUBTOTAL					\$	225,000	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Clearing & Vegetation/Debris Disposal							
Site Clearing & Disposal (Quanta Property)							
Temporary erosion controls (silt fencing)	2,624	LF	\$	1.28	\$	3,369	MEANS 31.25.13.10.1100 Surrounding property boundary
Clear and Grub Heavy Brush & Trees (includes chipper)	3	AC	\$	8,203	\$	24,610	MEANS 31.11.10.10.0260 Clear & grub brush, including stumps, assumes 20% of Quanta requires clearing
Tank pad concrete removal & sizing to less than 2 feet	5,645	TON	\$	128	\$	720,634	MEANS 02.41.13.17.5500 Concrete demolition, on grade slab, assumes 2' thick concrete pads on 20% of Quanta site, 15% of pads are removed
Asphalt removal	3,969	SY	\$	3.76	\$	14,925	Source 3 Assumes 3" thick asphalt to be cleared from 15% of Quanta
Subsurface piping abandonment	1	LS	\$	250,000	\$	250,000	Engineer's Estimate
Offsite disposal of cleared materials, concrete (including transportation to < 50 miles)	3,528	CY	\$	205	\$	723,316	MEANS 33-19-7270 Assumes HW landfill: Concrete pads + Clearing at 30 CY/AC
Asphalt Disposal	331	CY	\$	25	\$	8,275	Source 3
Dust suppression	20	DY	\$	820	\$	16,400	MEANS 31.23.23.18.4500 Concurrent site activities/dust control
SUBTOTAL					\$	1,761,529	
Site Clearing & Disposal (Block 93, 115 River Road)							
Temporary erosion controls (silt fencing)	2,100	LF	\$	1.28	\$	2,696	MEANS 31.25.13.10.1100 Surrounding property boundary
Asphalt removal	12,578	SY	\$	3.76	\$	47,294	Source 3 Assumes 3" thick asphalt to be cleared from 50% of Block 93 and 115 River Road
Asphalt Disposal	1,048	CY	\$	25	\$	26,200	Source 3
Dust suppression	5	DY	\$	820	\$	4,100	MEANS 31.23.23.18.4500 Concurrent site activities/dust control
SUBTOTAL					\$	80,290	
Site Clearing & Disposal (Edgewater - Arsenic Area)							
Temporary erosion controls (silt fencing)	1,500	LF	\$	1.28	\$	1,926	MEANS 31.25.13.10.1100 Surrounding property boundary
Concrete removal & sizing to less than 2'	6,061	TON	\$	118	\$	715,159	MEANS 02.41.13.17.5500 Concrete demolition of access ramp, assumes 2-ft of concrete
Asphalt removal	6,361	SY	\$	3.76	\$	23,918	Source 3 Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Offsite disposal of concrete (including transportation to < 50 miles)	3,367	CY	\$	130	\$	437,715	MEANS 33-19-7270 Assumes non-HW landfill
Asphalt Disposal	530	CY	\$	25	\$	13,250	Source 3
Dust suppression	40	DY	\$	820	\$	32,801	MEANS 31.23.23.18.4500 Concurrent site activities/dust control
Dig Permits & Utility Markout	10	DY	\$	3,000	\$	30,000	Source 3
Excavation, stockpile and backfill of 10-ft of soils above the existing arsenic liner	21,204	CY	\$	35	\$	750,473	MEANS 17-03-0276 Assumes material will be replaced following the completion of arsenic stabilization
Temporary Access	1	allow	\$	65,000	\$	65,000	
SUBTOTAL					\$	2,070,241	
Site Clearing & Disposal (Edgewater - NZ-5)							
Temporary erosion controls (silt fencing)	750	LF	\$	1.28	\$	963	MEANS 31.25.13.10.1100 Surrounding property boundary
Asphalt removal	1,505	SY	\$	3.76	\$	5,660	Source 3 Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Asphalt Disposal	125	CY	\$	25	\$	3,125	Source 3
Dust suppression	20	DY	\$	820	\$	16,400	MEANS 31.23.23.18.4500 Concurrent site activities/dust control
Dig Permits & Utility Markout	5	DY	\$	3,000	\$	15,000	Source 3

Alternative 6: Excavation - DRAFT

COST ESTIMATE SUMMARY

Excavation, Backfilling, & Soil Disposal

Dig Permits & Utility Markout	10	DAY	\$	3,000	\$	30,000	Source 3	
Excavation of Shallow NAPL	78,505	CY	\$	30	\$	2,355,150	MEANS 17-03-0276	
Excavation of Arsenic soils	41,095	CY	\$	30	\$	1,232,850	MEANS 17-03-0276	
Excavation of Tar Boils Quanta	6,075	CY	\$	30	\$	182,250	MEANS 17-03-0276	
Certified clean fill for backfilling excavated areas	150,810	CY	\$	18	\$	2,669,709	Source 3	
Dust suppression	360	DY	\$	820	\$	295,205	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Odor suppression	360	DY	\$	1,000	\$	360,000	Source 3	
Dewatering (during excavations below 4' bgs)	52	WK	\$	2,220	\$	115,440	Source 3	Assume 4 sets of equipment required
Sheet piling	48,900	SF	\$	62	\$	3,031,800	Source 3	Assumed sheet piling required along roadside for Arsenic excavation (sheet piling 30' deep)
Shoring around buildings	5,000	LF	\$	62	\$	2,480,000		Assumes sheet pile will be driven 8 feet bgs
On-site stabilization of excavated contaminated soils with Portland Cement	207,364	TON	\$	35	\$	7,257,731	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 Tons/CY
Disposal of stabilized contaminated soil - Non-Haz Waste	144,526	CY	\$	130	\$	18,788,413	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in weight from add'l material, 2.0 Tons/CY)
SUBTOTAL					\$	38,798,548		

Compliance Monitoring and Health & Safety

Environmental Controls	1	LS	\$	58,000	\$	58,000	Source 4	
Analytical Requirements	250,022	CY	\$	2.60	\$	650,057	Source 3	Based on total materials to be disposed
Install Decon Shed for workers (Mobilization & Demobilization)	1	LS	\$	500	\$	500	Source 3	
Decon Shed	20	MO	\$	1,043	\$	20,851	Source 4	
Air Monitoring	120	DY	\$	718	\$	86,100	Source 4 + CH2M H&S	
PPE Provisions for Workers (Initial)	30	EA	\$	252	\$	7,557	Source 4	12 labor, 8 operator, 8 trucks, 2 supervisor
PPE Provisions for Workers (Worker-Days)	13,200	EA	\$	21	\$	279,760	Source 4 + CH2M H&S	
SUBTOTAL					\$	1,102,824		

Capping

New Engineered Impermeable Cap (Block 93 North, Block 93 Central, Block 93 South and 115 River Road)

Rough site grading	17,244	SY	\$	5.15	\$	88,731	MEANS 17-03-0101	Assume no clean fill needed, no clearing unless included above, asphalt removal & disposal included above
Fine grading	17,244	SY	\$	1.42	\$	24,515	MEANS 17-03-0101	Assume no fill needed for grading
Gravel Base, 6 inches	2,874	CY	\$	53	\$	153,685	MEANS 32.11.23.23.1511	Assume no fill needed for grading
Dust suppression	15	DY	\$	820	\$	12,300	MEANS 31.23.23.18.4500	Cost for Geosynthetic Drainage Material (non-ideal conditions) was more \$\$
Storm water control (3' x 3' culverts, rip-rap)	6	EA	\$	7,204	\$	43,224	Source 4	Concurrent site activities/dust control
Asphalt stabilized binder course, 2" thick	17,244	SY	\$	23	\$	394,698	MEANS 32.12.16.13.0120	Included 2 storm water control systems per capped property
Asphalt wear course, 2" thick	17,244	SY	\$	23	\$	404,053	MEANS 32.12.16.13.0380	
Install Asphalt Curb/Berm on Perimeter	2,000	LF	\$	11	\$	22,080	MEANS 32.16.19.10.0150	
SUBTOTAL					\$	1,143,286		

New Cap (115 River Road Property - Basement Area)

Clear & disposal of basement materials (equipment, etc.)	16,722	SF	\$	0.43	\$	7,239	MEANS 02.41.19.19.0300	Assumption: 1 ton of mtrl & equip/250sf (15.81' x 15.81')
Abandon/Demo Basement Facility Trench Drains (trenching, concrete, grating)	1,700	LF	\$	68	\$	115,600	MEANS 22.14.26.19.6650	
Disposal of Basement Demo Material	1	LS	\$	10,000	\$	10,000	Estimator Judgement	
Install HDPE liner	1,858	SF	\$	15	\$	28,669	MEANS 02.660.610.1200	
Fill Basement with 2 feet of Fill	1,239	CY	\$	53	\$	66,237	MEANS 32.11.23.23.1511	
Fill Basement with 2 feet of Concrete	1,239	CY	\$	206	\$	255,374	MEANS 03.31.05.70.4300	Normal weight concrete and placement
Insulation	16,722	SF	\$	2	\$	33,444		
SUBTOTAL					\$	516,563		

Replacement of Access Ramp and Parking Lots (Edgewater)

Backfilling and compaction of excavated material	21,204	CY	\$	18	\$	375,358	MEANS 17-03-0423	Assume no clean fill needed, no clearing unless included above
Rough site grading	8,275	SY	\$	5.15	\$	42,580	MEANS 17-03-0101	Assumes 1.2x excavated material required for compaction
Fine grading	8,275	SY	\$	1.42	\$	11,764	MEANS 17-03-0101	Assume no fill needed for grading
Gravel Base, 6 inches	1,379	CY	\$	53	\$	73,741	MEANS 32.11.23.23.1511	Assume no fill needed for grading
Dust suppression	60	DY	\$	820	\$	49,201	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Storm water control (3' x 3' culverts, rip-rap)	2	EA	\$	11,638	\$	23,275	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	8,275	SY	\$	23	\$	189,407	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	8,275	SY	\$	23	\$	193,896	MEANS 32.12.16.13.0380	
Install Asphalt Curb/Berm on Perimeter	2,500	LF	\$	11	\$	27,600	MEANS 32.16.19.10.0150	
SUBTOTAL					\$	986,821		

Alternative 6: Excavation - DRAFT

COST ESTIMATE SUMMARY

New Vegetative Cap (Assumes 50% of the Property will include a Engineering Cap with Drainage Layer)						Silt fence around Quanta property included under engineered cap	
Rough grading	24,774	SY	\$	5.15	\$	127,478	MEANS 17-03-0101
Fine grading	24,774	SY	\$	1.42	\$	35,221	MEANS 17-03-0101
Protective layer, 12" compacted soil subgrade	8,258	CY	\$	18	\$	146,188	MEANS 17-03-0423
HDPE Liner, 40 mil thick	12,387	SY	\$	15	\$	191,133	ECHOS 33.08.0572
Drainage layer, 6" granular soil (assume gravel)	2,065	CY	\$	53	\$	110,399	MEANS 32.11.23.23.1511
Grade, Place Geotextile filter fabric	24,774	SY	\$	2.00	\$	49,548	Source 3
Vegetative layer, 18" soil	12,387	CY	\$	18	\$	219,282	MEANS 17-03-0423
Top soil, 6"	4,129	CY	\$	30	\$	123,871	MEANS 31.05.13.10.0800
Dust suppression	45	DY	\$	820	\$	36,901	MEANS 31.23.23.18.4500
Hydroseed	222,968	SF	\$	0.07	\$	15,608	Source 3
Watering	223	MSF	\$	56	\$	12,452	MEANS 32.01.09.26.4900
SUBTOTAL					\$	1,068,081	
Compliance Monitoring and Health & Safety						Based on 1" of water per 1,000 sf, 4 -watering events (.25-in per event)	
Environmental Controls	1	LS	\$	13,000	\$	13,000	Source 4
Analytical Requirements	8,623	CY	\$	2.6	\$	22,420	Source 3
Install Decon Shed for workers (Mobilization & Demobilization)	1	LS	\$	500	\$	500	Source 3
Decon Shed	3	MO	\$	1,043	\$	3,128	Source 4
Air Monitoring	32	DY	\$	718	\$	22,960	Source 4 + CH2M H&S
PPE Provisions for Workers (Initial)	20	EA	\$	252	\$	5,038	Source 4
PPE Provisions for Workers (Worker-Days)	1,320	EA	\$	21	\$	27,976	Source 4 + CH2M H&S
SUBTOTAL					\$	95,021	
Wastewater Treatment Plant to Treat Excavation Water						Option to treat excavation water before discharge to the river.	
Pumping and Equalization of Influent Water						Provides 8-hrs of storage at 100 gpm	
8,000 gallon polypropylene equalization tanks	2	EA	\$	12,605	\$	25,211	Source 3
Sludge pump	1	EA	\$	3,864	\$	3,864	Source 3
Off-gas pump	1	EA	\$	1,322	\$	1,322	Source 3
50 GPM effluent pump (MAX @ 65 TDH)	4	EA	\$	4,221	\$	16,883	Source 3
NAPL pump	1	EA	\$	3,864	\$	3,864	Source 3
Chemical feed systems (caustic and acid)	2	EA	\$	3,130	\$	6,260	Source 3
SUBTOTAL					\$	57,404	
Removal of NAPLs and Solids							
Oil-water separator, 50 gpm	2	EA	\$	16,910	\$	33,820	ECHOS 19.04.0412
Packaged 1,500 Gallon Steel Product Tank	1	EA	\$	4,950	\$	4,950	ECHOS 19.04.0604
Packaged 20 gpm Oil Pump out unit w/controls	2	EA	\$	7,670	\$	15,340	ECHOS 33.13.1211
50 GPM effluent pump (two in operation and one in stand-by)(MAX@ 65 TDH)	3	EA	\$	4,200	\$	12,600	Source 3
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	\$	3,130	\$	15,650	Source 3
SUBTOTAL					\$	82,360	
Advanced oxidation							
Flocculation tanks connected in series	4	EA	\$	4,362	\$	17,450	Source 3
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	\$	3,130	\$	15,650	Source 3
Waste sludge pumps (Non-clogging with double vortex impellers to handle heavy sludge)	2	EA	\$	3,864	\$	7,728	Source 3
SUBTOTAL					\$	40,828	
Solid-liquid Separation							
Inclined plate clarifier (0.25 GPM/SF of area)	6	EA	\$	26,520	\$	159,120	ECHOS 33.13.0414
100 GPM effluent pump for use with plate clarifier	2	EA	\$	6,211	\$	12,423	Source 3
Sludge pump for use with plate clarifier	1	EA	\$	800	\$	800	Source 3
Bag filters	4	EA	\$	800	\$	3,200	Source 3
Offgas pumps for use with bag filters	4	EA	\$	4,221	\$	16,883	Source 3
Effluent pumps for use with bag filters	4	EA	\$	4,221	\$	16,883	Source 3
Liquid waste pump for use with sludge settling tank	2	EA	\$	90,000	\$	180,000	Source 3
Filter press, 95% removal efficiency	4	EA	\$	90,100	\$	360,400	ECHOS 33.33.3013
SUBTOTAL					\$	749,709	
Effluent Polishing						Includes GAC, pumps, tanks	
Packaged 36,000 GPD water treatment plant	4	EA	\$	32,400	\$	129,600	ECHOS 19.01.0807
Concrete Wet Well, 12'x36"	6	EA	\$	9,200	\$	55,200	ECHOS 19.02.0304
Packaged Lift Station (70 gpm)	6	EA	\$	9,950	\$	59,700	ECHOS 19.02.0304
Ion exchange units (one in operation and one standby and/or in regeneration phase)	4	EA	\$	10,000	\$	40,000	CH2M HILL Est.
SUBTOTAL					\$	284,500	
Building & Controls							
Building / HVAC / Electrical	1	EA	\$	150,000	\$	150,000	Source 3
SCADA Computer Control System	1	LS	\$	400,000	\$	400,000	CH2M HILL Est.
SUBTOTAL					\$	550,000	
Piping, Instrumentation, & Equipment Installation							
Schedule 80 PVC piping (including T-connections, elbows, valves, flanges, and reducers)	2000	LF	\$	24	\$	48,000	Source 3
Carbon steel piping (including T-connections, elbows, valves, flanges, and reducers)	1000	LF	\$	67	\$	67,000	Source 3
Pipe supports, misc metals	1	LS	\$	60,000	\$	60,000	CH2M HILL Est.
Equipment Installation	25	DY	\$	3,000	\$	75,000	CH2M HILL Est.
Concrete Pad	1	LS	\$	50,000	\$	50,000	CH2M HILL Est.
Plumbing, Fire Suppression	1	LS	\$	30,000	\$	30,000	CH2M HILL Est.
Permits	1	LS	\$	4,000	\$	4,000	CH2M HILL Est.
Utility Connections	1	LS	\$	7,000	\$	7,000	CH2M HILL Est.
Chemical Reagents	1	LS	\$	20,000	\$	20,000	CH2M HILL Est.
550 Gallon double walled tanks for chemical storage	5	EA	\$	2,728	\$	13,638	Source 3
Instrumentation and automated controls for chemical feed systems (metering pumps, tanks gauges, back pressure regulators, strainers, pressure relief valves, flow-meters, check valves, manual valves)	1	LS	\$	100,000	\$	100,000	Source 3
SUBTOTAL					\$	474,638	
System Startup						150,000 CH2M HILL Est.	
	1	LS	\$	150,000	\$	150,000	

Alternative 6: Excavation - DRAFT				COST ESTIMATE SUMMARY			
Compliance Monitoring and Health & Safety							
Environmental Controls	1	LS	\$	13,000	\$	13,000	Source 4
Discharge permit	1	LS	\$	50,000	\$	50,000	Estimator Judgement
Air Monitoring	200	DY	\$	718	\$	143,501	Source 4 + CH2M H&S
PPE Provisions for Workers (Initial)	12	EA	\$	252	\$	3,023	Source 4
PPE Provisions for Workers (Worker Days)	792	EA	\$	21	\$	16,786	Source 4 + CH2M H&S
SUBTOTAL					\$	226,309	4 labor, 2 operator, 4 pipefitters, 2 supervisor
CAPITAL SUBTOTAL - SOIL					\$	58,871,679	
Contingency	25%				\$	14,717,920	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11
SUBTOTAL					\$	73,589,599	
Project Management				5%	\$	3,679,480	USEPA 2000, p. 5-13, > \$10M
Remedial Design				6%	\$	4,415,376	USEPA 2000, p. 5-13, > \$10M
Construction Management				6%	\$	4,415,376	USEPA 2000, p. 5-13, > \$10M
SUBTOTAL					\$	12,510,232	
Contractor Fees							
ODC & Subs	5%		\$	73,589,599	\$	3,679,480	Calculate as 5% of capital cost
Labor	10%	max	\$	12,510,232	\$	1,251,023	Calculate as 10% of labor cost
SUBTOTAL					\$	4,930,503	
TOTAL CAPITAL COST - SOIL					\$	91,030,333	
GROUNDWATER							
General							
Mobilization/Demobilization	5%		\$	1,464,000	\$	73,200	Calculate as 5% of capital cost
Subcontractor General Conditions	10%		\$	1,464,000	\$	146,400	Calculate as 10% of capital cost
SUBTOTAL					\$	219,600	
Replacement Monitoring Wells							
Soil Borings	480	FT	\$	47	\$	22,320	Assumes 16 wells at 30-ft deep
2-inch PVC Well Casing	480	FT	\$	15	\$	7,109	
2-inch PVC Well Screen	160	FT	\$	25	\$	4,003	Assumes 10-ft screen
2-inch PVC Riser	320	FT	\$	15	\$	4,739	
Well cuttings disposal	16	EA	\$	100	\$	1,600	Assumes one 55-gal drum per well
Well development	16	EA	\$	1,600	\$	25,600	
SUBTOTAL					\$	65,371	
Site Preparation							
Erosion Control	1	LS	\$	20,000	\$	20,000	
Permitting	1	LS	\$	150,000	\$	150,000	
Survey (pre and post installation)	2	EA	\$	2,500	\$	5,000	
Staging Pad	1	LS	\$	10,000	\$	10,000	
Rental and operation of generator	1	MO	\$	17,050	\$	17,050	\$150/dy rent + \$400/dy fuel = \$550/dy
Rental of frac tank	1	MO	\$	500	\$	500	
Portadam® Barriers - Setup, teardown, and one month rental	1,200	LF	\$	100	\$	120,000	
Portadam® Barriers - Additional rental	2	WK	\$	15,600	\$	31,200	
Cut-Off Timber Piles Allowance	1	LS	\$	150,000	\$	150,000	
SUBTOTAL					\$	503,750	
Excavate 2' of Impacted Sediment							
Pump out area within Portadams®	30	DY	\$	1,275	\$	38,250	Source 3 750 GPM Godwin Dri-Prime 6" Model CD150M
Pump fuel and oil	1,500	GAL	\$	4	\$	6,000	Source 3 3.1 GPH Diesel Fuel x 24 hrs/day x 20 days
Excavate 2' sediment from dewatered area	11,000	CY	\$	25	\$	275,000	Source 3 Assumed area 160' x 950'
Transportation of material back to staging pad	11,000	CY	\$	4	\$	44,000	Source 3
SUBTOTAL					\$	363,250	
Install RCM Mat & Armor Layer							
Organoclay RCM material	120	ROLL	\$	3,000	\$	360,000	Source 3 20% extra for overlap - 1,500 ft2/roll x \$2.00/ft2
Install organoclay RCM	150,000	SF	\$	1	\$	75,000	Source 3
12" sand armor layer (material only)	6,000	CY	\$	20	\$	120,000	Source 3
Install 12" sand armor layer	6,000	CY	\$	7	\$	42,000	Source 3
SUBTOTAL					\$	597,000	
CAPITAL SUBTOTAL - Groundwater					\$	1,748,971	
Contingency	25%				\$	437,243	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11
SUBTOTAL					\$	2,186,213	
Project Management				5%	\$	109,311	USEPA 2000, p. 5-13, \$2M - \$10M
Remedial Design				8%	\$	174,897	USEPA 2000, p. 5-13, \$2M - \$10M
Construction Management				6%	\$	131,173	USEPA 2000, p. 5-13, \$2M - \$10M
SUBTOTAL					\$	415,381	
Contractor Fees							
ODC & Subs	5%		\$	2,186,213	\$	109,311	Calculate as 5% of capital cost
Labor	10%	max	\$	415,381	\$	41,538	Calculate as 10% of labor cost
SUBTOTAL					\$	150,849	
TOTAL CAPITAL COST - GROUND WATER					\$	2,750,000	
SOIL							
OPERATIONS AND MAINTENANCE COST							
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES		
Cap Maintenance							
Cap Repair	1	LS	\$	25,596	\$	25,596	Assumes 1% of area requires repair annually, cap costs are based on repaving and maintaining the soil cap at Quanta
Cap Inspection and Repair Report	1	LS	\$	2,000	\$	2,000	Biennial Report to NJDEP
Fan System Maintenance (115 River Road)	8	HR	\$	80	\$	640	
SUBTOTAL					\$	28,236	
Contingency	25%				\$	7,059	10% Scope + 15% Bid
SUBTOTAL					\$	35,295	
Project Management				5%	\$	1,765	
Technical Support				25%	\$	8,824	
SUBTOTAL					\$	10,589	
Contractor Fees							
ODC & Subs	5%		\$	35,295	\$	1,765	Calculate as 5% of capital cost
Labor	10%	max	\$	10,589	\$	1,059	Calculate as 10% of labor cost
SUBTOTAL					\$	2,824	
TOTAL ANNUAL O&M COST - Soil (Year 1 to 30)					\$	48,700	

Alternative 6: Excavation - DRAFT

COST ESTIMATE SUMMARY

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
2 Year Biennial Certification	2	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	4	1	LS	\$ 4,613	\$ 4,613	
5 year Review	5	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	6	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	8	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	10	1	LS	\$ 4,613	\$ 4,613	
5 year Review	10	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	12	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	14	1	LS	\$ 4,613	\$ 4,613	
5 year Review	15	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road	15	1	LS	\$ 5,000	\$ 5,000	
2 Year Biennial Certification	16	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	18	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	20	1	LS	\$ 4,613	\$ 4,613	
5 year Review	20	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	22	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	24	1	LS	\$ 4,613	\$ 4,613	
5 year Review	25	1	LS	\$ 15,000	\$ 15,000	
2 Year Biennial Certification	26	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	28	1	LS	\$ 4,613	\$ 4,613	
2 Year Biennial Certification	30	1	LS	\$ 4,613	\$ 4,613	
5 year Review	30	1	LS	\$ 15,000	\$ 15,000	
Replace Fans in 115 River Road	30	1	LS	\$ 5,000	\$ 5,000	
Asphalt Cap Replacement	30	1	LS	\$ 663,410	\$ 663,410	Assume complete replacement of 30% of cap after 30 years
TOTAL ANNUAL PERIODIC COST					\$ 830,000	

PRESENT VALUE ANALYSIS

Discount Rate = 7.0%

Source: USEPA 2000, page 4-5. This rate represents a "real" discount rate approximating interest rates adjusted for inflation. Annual & periodic costs should be constant in this analysis.

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 91,030,333	\$ 91,030,333	1	\$ 91,030,333	
ANNUAL O&M COST - Cap	1 to 30	\$ 1,461,000	\$ 48,700	12.41	\$ 604,320	
PERIODIC COST	2	\$ 4,613	\$ 4,613	0.87	\$ 4,029	
PERIODIC COST	4	\$ 4,613	\$ 4,613	0.76	\$ 3,519	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	6	\$ 4,613	\$ 4,613	0.67	\$ 3,074	
PERIODIC COST	8	\$ 4,613	\$ 4,613	0.58	\$ 2,685	
PERIODIC COST	10	\$ 19,613	\$ 19,613	0.51	\$ 9,970	
PERIODIC COST	12	\$ 4,613	\$ 4,613	0.44	\$ 2,048	
PERIODIC COST	14	\$ 4,613	\$ 4,613	0.39	\$ 1,789	
PERIODIC COST	15	\$ 20,000	\$ 20,000	0.36	\$ 7,249	
PERIODIC COST	16	\$ 4,613	\$ 4,613	0.34	\$ 1,563	
PERIODIC COST	18	\$ 4,613	\$ 4,613	0.30	\$ 1,365	
PERIODIC COST	20	\$ 19,613	\$ 19,613	0.26	\$ 5,068	
PERIODIC COST	22	\$ 4,613	\$ 4,613	0.23	\$ 1,041	
PERIODIC COST	24	\$ 4,613	\$ 4,613	0.20	\$ 909	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	26	\$ 4,613	\$ 4,613	0.17	\$ 794	
PERIODIC COST	28	\$ 4,613	\$ 4,613	0.15	\$ 694	
PERIODIC COST	30	\$ 688,023	\$ 688,023	0.13	\$ 90,384	
TOTAL PRESENT VALUE FOR SOIL					\$ 91,780,000	

GROUNDWATER

OPERATIONS AND MAINTENANCE COST

Inspection of Subaqueous Reactive Barrier (SRB)						
Sampling of barrier during low tide	1	LS	\$ 15,000	\$ 15,000	Excavator onsite for 5 days--expose 5% of barrier every 5 years	
Barrier replacement	1	LS	\$ 149,250	\$ 149,250	25% of barrier every 5 years	
SUBTOTAL				\$ 164,250		
Allowance for Misc. Items	20%			\$ 32,850		
SUBTOTAL				\$ 197,100		
Contingency	25%			\$ 49,275	10% Scope + 15% Bid	
SUBTOTAL				\$ 246,375		
Project Management	5%			\$ 12,319		
Technical Support	25%			\$ 61,594		
				\$ 73,913		
Contractor Fees						
ODC & Subs	5%		\$ 246,375	\$ 12,319	Calculate as 5% of capital cost	
Labor	10%	max	\$ 73,913	\$ 7,391	Calculate as 10% of labor cost	
SUBTOTAL				\$ 19,710		
TOTAL FOR SRB O&M				\$ 340,000		
Groundwater Monitoring						
Groundwater Samples	16	EA	\$ 645	\$ 10,320	Pesticides, TAL Metals	
QC Samples	5	EA	\$ 645	\$ 3,225	Historical Pricing	
Groundwater Sampling, Level D						
Labor	150	HR	\$ 80	\$ 12,000	CH2M Est. - 3 persons for 5 days	
Equipment - meters	1	LS	\$ 500	\$ 500	CH2M Est.	
Consumables	1	LS	\$ 200	\$ 200	CH2M Est.	
Data Validation	24	HR	\$ 80	\$ 1,920	CH2M Est.	
Reporting	50	HR	\$ 80	\$ 4,000	CH2M Est.	
SUBTOTAL				\$ 32,165		
Allowance for Misc. Items	20%			\$ 6,433		
SUBTOTAL				\$ 38,598		
Contingency	25%			\$ 9,650	10% Scope + 15% Bid	
SUBTOTAL				\$ 48,248		
Project Management	5%			\$ 2,412		
Technical Support	25%			\$ 12,062		
				\$ 14,474		
Contractor Fees						
ODC & Subs	5%		\$ 48,248	\$ 2,412	Calculate as 5% of capital cost	
Labor	10%	max	\$ 14,474	\$ 1,447	Calculate as 10% of labor cost	
SUBTOTAL				\$ 3,860		
TOTAL FOR GROUNDWATER SAMPLING EVENT				\$ 66,600		
TOTAL ANNUAL O&M COST Year 0 to 2				\$ 266,400	Quarterly for 2 years	
TOTAL ANNUAL O&M COST Year 3 to 30				\$ 66,600	Annually	
TOTAL ANNUAL O&M COST Year 5, 10, 15, 20, 25, 30				\$ 340,000	Cap maintenance	

Alternative 6: Excavation - DRAFT				COST ESTIMATE SUMMARY		
PERIODIC COSTS						
DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
5 year Review	5	1	LS	\$	15,000	\$ 15,000
5 year Review	10	1	LS	\$	15,000	\$ 15,000
Reapplication for the CEA (Deed)	10	1	LS	\$	25,000	\$ 25,000
5 year Review	15	1	LS	\$	15,000	\$ 15,000
5 year Review	20	1	LS	\$	15,000	\$ 15,000
Reapplication for the CEA (Deed)	20	1	LS	\$	25,000	\$ 25,000
5 year Review	25	1	LS	\$	15,000	\$ 15,000
5 year Review	30	1	LS	\$	15,000	\$ 15,000
Reapplication for the CEA (Deed)	30	1	LS	\$	25,000	\$ 25,000
					\$	165,000
TOTAL ANNUAL PERIODIC COST					\$	170,000

PRESENT VALUE ANALYSIS		Discount Rate =		7.0%		
COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST	0	\$ 2,750,000	\$ 2,750,000	1.00	\$ 2,750,000	
ANNUAL O&M COST (Year 0-2)	0 to 2	\$ 532,800	\$ 266,400	1.81	\$ 481,656	
ANNUAL O&M COST (Year 3-30)	3 to 30	\$ 1,864,800	\$ 66,600	10.60	\$ 706,028	
ANNUAL O&M COST (Year 5)	5	\$ 340,000	\$ 340,000	0.71	\$ 242,415	
ANNUAL O&M COST (Year 10)	10	\$ 340,000	\$ 340,000	0.51	\$ 172,839	
ANNUAL O&M COST (Year 15)	15	\$ 340,000	\$ 340,000	0.36	\$ 123,232	
ANNUAL O&M COST (Year 20)	20	\$ 340,000	\$ 340,000	0.26	\$ 87,862	
ANNUAL O&M COST (Year 25)	25	\$ 340,000	\$ 340,000	0.18	\$ 62,645	
ANNUAL O&M COST (Year 30)	30	\$ 340,000	\$ 340,000	0.13	\$ 44,665	
PERIODIC COST	5	\$ 15,000	\$ 15,000	0.71	\$ 10,695	
PERIODIC COST	10	\$ 40,000	\$ 40,000	0.51	\$ 20,334	
PERIODIC COST	15	\$ 15,000	\$ 15,000	0.36	\$ 5,437	
PERIODIC COST	20	\$ 40,000	\$ 40,000	0.26	\$ 10,337	
PERIODIC COST	25	\$ 15,000	\$ 15,000	0.18	\$ 2,764	
PERIODIC COST	30	\$ 40,000	\$ 40,000	0.13	\$ 5,255	
					\$	4,726,163
TOTAL PRESENT VALUE FOR GROUNDWATER					\$	4,730,000

Total Present Value for Alternative 6	\$96,510,000
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SOURCE INFORMATION	
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2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)	
2b. R.S. Means Company. 2007. 26th Edition.	
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.	
3. Historical CH2M HILL project cost information	
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)	